HYDROGEOLOGICAL REPORT

HYDROGEOLOGICAL REPORT OF LEPHALALE COAL CONCESSIONS (PTY) LTD IN SUPPORT OF THE WATER USE LICENSE AND WASTE MANAGEMENT LICENSE APPLICATIONS OF THE COAL MINING RIGHT ON THE EXTENT OF THE FARM MINNASVLAKTE 258 LQ, SMITSPAN 306 LQ, MASSENBERG 305 LQ AND REMAINDER OF HOOIKRAAL 315 LQ UNDER LEPHALALE LOCAL MUNICIPALITY IN LIMPOPO PROVINCE.

DMRE REF: LP 30/5/1/2/3/2/1 (184) EM

DWS REF NO: WU17879

PREPARED FOR

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2020

Project Information

Report Type	Geohydrological Report
Project Title:	Hydrogeological report in support of the water use license and waste management license applications for coal mining right on farms: Minnasvlakte 258 LQ, Smithspan 306 LQ, Massenberg 305 LQ & RE of Hooikraal 315 LQ, located under the magisterial district of Ellisras in the Limpopo Province.
Mineral	Coal
Site Location	Ellisras Magisterial District, Limpopo
Compiled For	Lephalale Coal Concessions (Pty) Ltd
Version	2020 Updated hydrogeological study
Date	12 October 2020

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Disclaimer:

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Executive Summary

Singo Consulting (Pty) Ltd was appointed by Lephalale Coal Concessions (Pty) Ltd to conduct a detailed hydrogeological study for the proposed water use license and waste license application on farms: Minnasvlakte 258 LQ, Smithspan 306 LQ, Massenberg 305 LQ & RE of Hooikraal 315 LQ, located under the magisterial district of Ellisras in the Limpopo Province, South Africa. This current hydrogeological study serves as an update of the hydrogeological study conducted by Future Flow GPMS cc on the 25th of July 2011.

The water use license was lodged and the reference number: WU17879. A waste license application was lodged with DMRE (reference number: 30/1/5/3/2/184EM). The extent of the mining right covers the above-mentioned farms.

The mining operation will trigger some activities that are listed in section 21 of the National water act (NWA). The following table illustrates some of these activities:

Table 1: Water uses triggered by the project

NWA Section 21	**Description of the water use**
21 (a)	Taking water from a water resource. - Boreholes which will be used for domestic purposes - Coal washing plant as its re-use of water for processing
21 (b)	Storing water - Water will be stored in reservoirs
21(g)	Disposing of waste in a manner which may detrimentally impact on a water resource - Storage of contaminated water in the PCD - Product stockpile - Conservancy tanks - Overburden stockpile
21(j)	Removing, discharging, or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people - Mine dewatering - Dust Suppression

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- Discard dump

This report outlines the details of the findings obtained during the investigation of hydrogeology in the area. This is a significant report as it outlines the following aspects related to the proposed activity:

- Groundwater modelling
- Groundwater impact assessment and mitigation measures
- Properly designed monitoring plan

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1 Introduction

1.1 Background information

Singo Consulting (Pty) Ltd was appointed by Lephalale Coal Concessions (Pty) Ltd (LCC) to conduct a detailed hydrogeological study for the water use license and waste license application on farms: Minnasvlakte 258 LQ, Smithspan 306 LQ, Massenberg 305 LQ & RE of Hooikraal 315 LQ, located under the magisterial district of Ellisras in the Limpopo Province, South Africa. This current hydrogeological study serves as an update of the hydrogeological study conducted by Future Flow GPMS cc on the 25th of July 2011.

LCC proposes to establish an opencast mine on the above-mentioned farms. The proposed opencast mining will span a period of 20 years and available information show that the mining pit will be to a depth of 60 m below ground level. The aim of this hydrogeological study is to identify and quantify the expected impacts on the surrounding aquifers (groundwater volumes and quality) from the proposed mining activities.

1.2 Scope of work

- Description of the baseline groundwater regime:
  - Conduct hydrocensus of existing boreholes, including groundwater use type and volume;
  - Ground geophysical investigation to identify preferential groundwater flow paths such as dolerite dyke contact zones and fractures.
  - Identification of monitoring boreholes during which hydrogeological data such as depth to water strike and groundwater quality will be monitored.
  - Laboratory testing of hydro-chemical samples.

- Environmental impact assessment using 3D numerical flow and contaminant transport modelling to calculate:
  - Groundwater inflow volumes into the mining area over the life of mine;
  - The cone of dewatering that forms due to mine dewatering and its development over time. This includes the impact on surrounding groundwater users;

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  - Contaminant transport away from point and diffuse sources within the mining area and the impacts on surrounding aquifers and users.
- Reporting:
  - Using the above components a final groundwater report is compiled.

1.3 Mine Water Definition

Mine water is a generalised term adopted to describe water from a range of sources generated from the mining and processing activities. It should be noted that terminology for 'mine water' has varied considerably in recent years and among different literature and also different geographic regions. For the purpose of this report, the term mine water is adopted from the contemporary definition of 'mine affected water'. This adopted definition of mine water is:

- Pit water, tailings dam water, processing plant water.
- Water contaminated by a mining activity which would have been an environmentally relevant activity under Schedule 2 of the Environmental Protection Regulation 2008 if it had not formed part of the mining activity.
- Rainfall runoff which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated. This excludes rainfall runoff discharging through release points associated with erosion and sediment control structures that have been installed to manage runoff containing sediment only, provided that this water has not been mixed with pit water, tailings dam water, processing plant water or workshop water.
- Groundwater which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated.
- Groundwater from the mine's dewatering activities.
- A mix of mine affected water and other water.

With this definition, descriptions of mine water in this report address the project's requirements to describe 'stormwater' and 'liquid waste'. Sewage effluent is not considered to be mine water.

For reference to descriptions of the water balance and water management herein, the mine water management system is defined as the combined influence and operation of:

- Catchments and drainage that collect mine waters (and exclude clean waters);
- Dams that capture and store mine water; and

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- The pumping or transfer infrastructure used to distribute mine water through the network for reuse in operations, or to make controlled compliant releases of mine water to downstream waterways.

The mine water management system performance is an assessment of the mine water management system's capability to adequately contain and manage excess mine water in very wet periods, supply mine water for reuse (particularly in dry periods), and ensure that controlled releases of mine water comply with the EA conditions.

1.4 Project location

Figure 1-1 below is a locality map illustrating the project area depicted by a black star on the map. The proposed mining operation is located in the farm Minnasvlakte 258 LQ, Smithspan 306 LQ, Massenberg 305 LQ & RE of Hooikraal 315 LQ, 15 km west from the town of Lephalale and 8km west of Medupi Power Station in Limpopo Province. The area falls within the Lephalale Local Municipality. There is a railway line located more than 10km east of the project area.

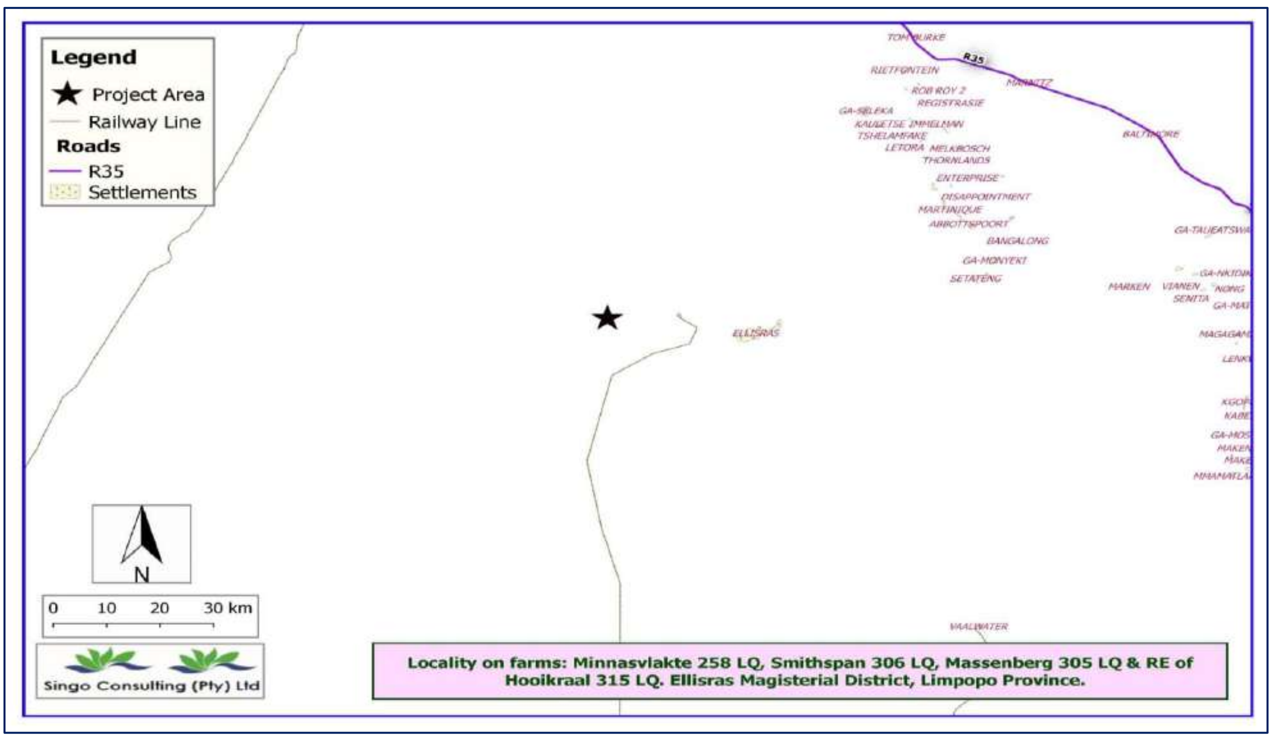

Figure 1-1: Locality map of the project area

2 Geographical setting

2.1 Topography and drainage

The topology of the area is illustrated below by Figure 2-1 below. A topographical map shows the physical features of the land. Besides just showing landforms such as mountains and rivers, the map also shows the elevation changes of the land. The topography of the project area is situated in a flat-lying topography ranges from 880-940 mamsl as displayed by the contour lines on the topology map below, there are no hills and mountains around the project area.

Elevation is shown using contour lines. When a contour line is drawn on a map it represents a given elevation. Every point on the map touching the line should be the same elevation. On some maps, numbers on the lines will let you know what the elevation is for that line. Contour lines next to each other will represent different elevations. The closer the contour lines are to each other, the steeper the slope of the land.

In this environmental project, topography is used to determine how soil can be conserved and how water will flow over the land. Data from topography can help to conserve the environment. By understanding the contour of the land, scientists can determine how water and wind may cause erosion. They can help to establish conservation areas such as watersheds and wind blocks. In this project contour lines indicates a lower chance of soil erosion as they are sparsely packed

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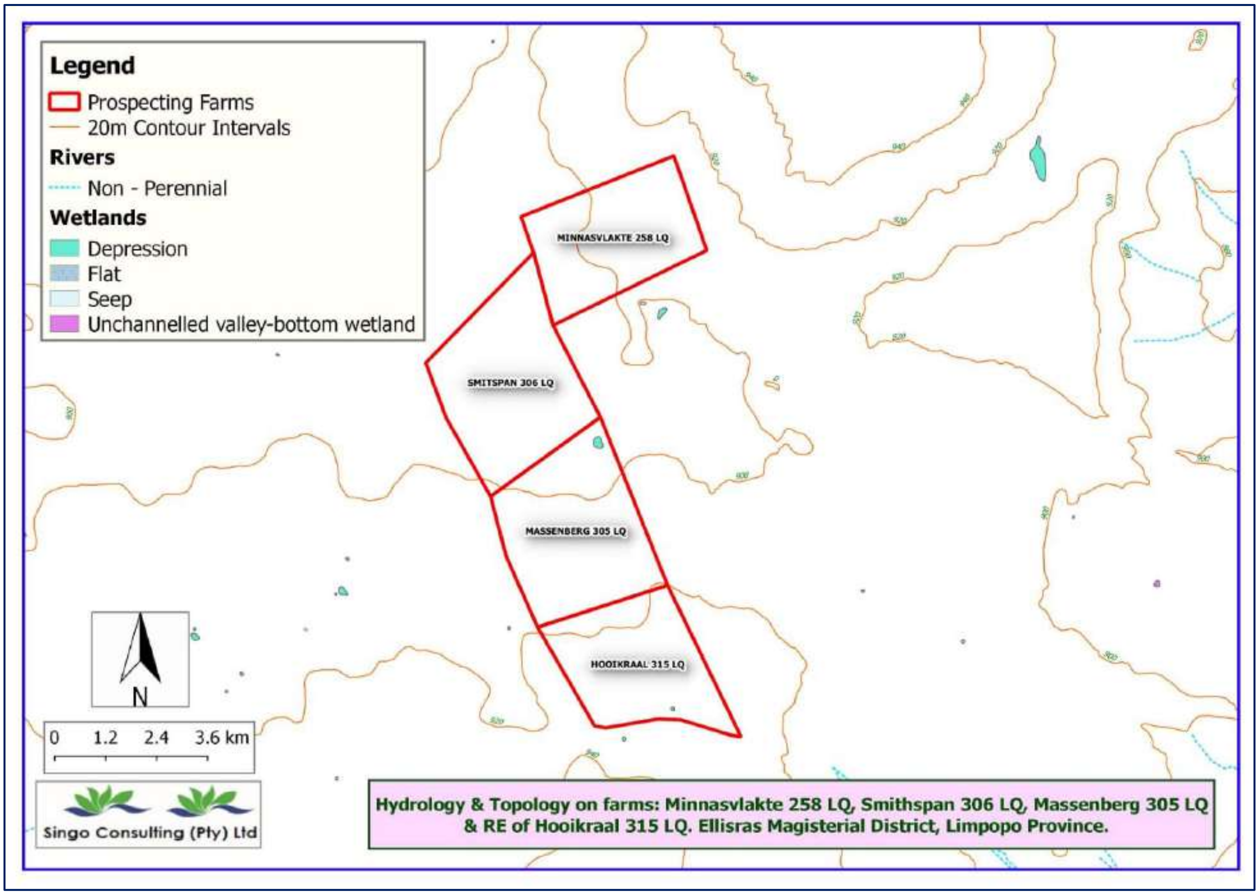

Figure 2-1: Topographical map of the project area

Hydrology

Figure 2-2 below is a hydrological map illustrating possible surface water bodies that can be found within and around the project area. The mining right activities will commence at the Hooikraal 315 LQ farm, within this farm no wetland type is detected. There are no channeled valley-bottom wetland nor any type of river observable within the vicinity of the mining right and according to the topography of this area, the underground water is possibly flowing from the eastern direction to the western direction following topography.

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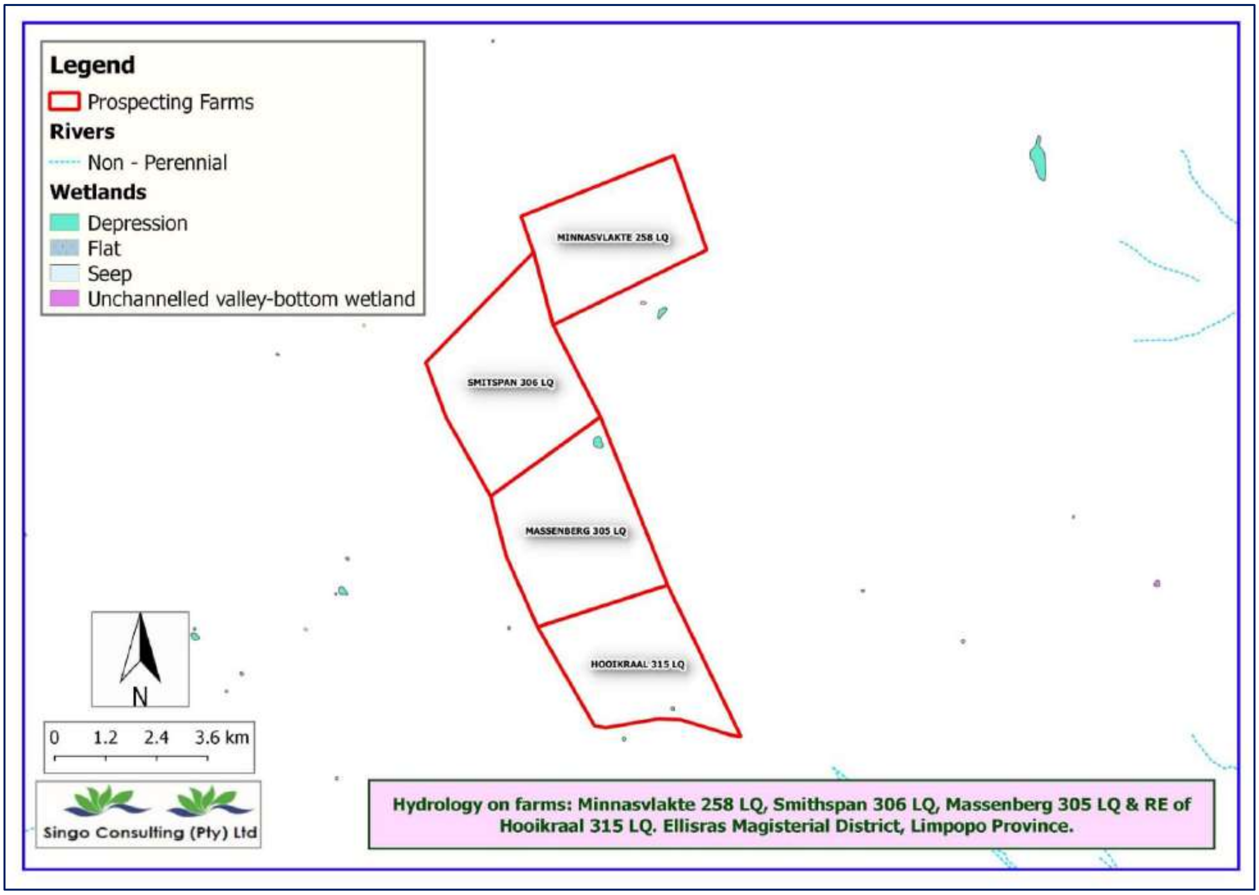

Figure 2-2: Hydrological map of the project area

2.2 Climate

Lephalale normally receives about 400 mm of rain per year, with most rainfall occurring mainly during mid-summer. This area receives the lowest rainfall (0mm) in June and the highest (81mm) in January. The monthly distribution of average daily maximum temperatures shows that the average midday temperatures for Lephalale range from 22.3°C in June to 31.9°C in January. The region is the coldest during July when the mercury drops to 3.7°C on average during the night.

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High and Low temperatures of Lephalale

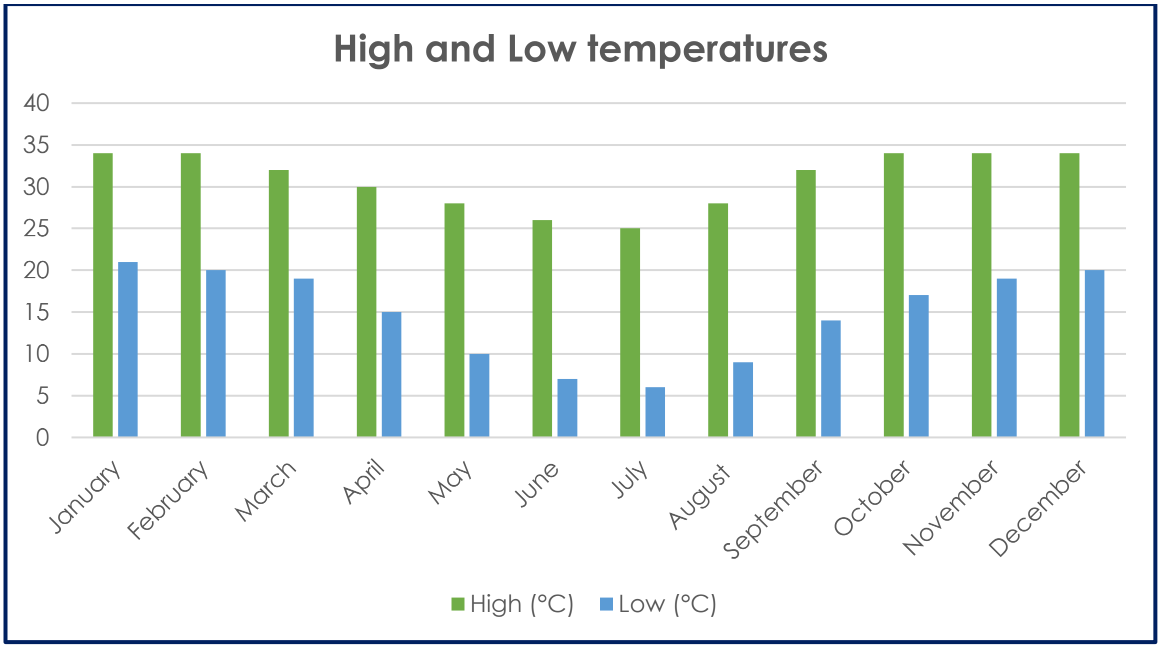

Figure 2-3: High and Low temperatures.

3 Terms of Reference

The baseline geohydrological assessment for the project area is mainly constructed by a combination of desktop study and site-specific field study. Most of the information used for this study was compiled with the aid of nearby study sites information and experience from similar geohydrological settings. All collected data will be compiled to construct a conceptual geohydrological model.

The objective of the study is to collect hydrogeological and geochemical baseline information to address the subsequent environmental impact assessment for the LCC mine. The impact assessment should be separated into pre-construction, construction, operational, decommissioning and closure and post closure phases. Management and mitigation measures for identified impacts should be outlined for each phase of the project and associated monitoring, management and mitigation measures recommended.

In order to quantify potential impacts of the various project phases on the ambient groundwater environment, a numerical groundwater flow and transport model for the project area will be developed.

The following aspects were covered in this hydrogeological study:

Table 3-1: Aspects of the hydrogeological study

Aspect	Description
Desktop Study	- Project Initiation and Data Collection - Review available site specific hydrogeological and hydrological information to conceptualize the different aquifer systems and their interaction with surface water features in the area.

Hydrogeological Modelling	- Interpret geochemical analyses of water samples conducted by Regen waters Lab
	- Numerical Groundwater Flow and Transport Model
	  - Model inputs
	  - Model Calibration
	  - Scenario Modelling
	  - Hydrogeological Impact Assessment
	  - Use the model to predict potential mining impacts on the shallow and deep groundwater flow systems, groundwater seepages and spring discharges

Aquifer classification	- Aquifers will be classified into either minor or major aquifer types and dominant water source will be identified
Groundwater levels	- A dip meter will be used to measure the water level at all the boreholes within the study site
Groundwater recharge	- Groundwater recharge will be calculated using the chloride method
Acid Base Accounting	- ABA tests will be conducted to check for acid producing potential

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Reporting	Writing a comprehensive geohydrological report outlining all the findings and existing environment of the proposed project area. This groundwater specialist report compiles all methodologies, findings, quantitative analysis (geochemical assessment and modelling outcomes), impact assessments, recommendations (proposed monitoring programme and recommended mitigation measures for predicted impacts) and conclusions. Appendices to the specialist report will include laboratory results.
Site visits	Site visit is the most significant part of the investigation, several site visits were conducted to collect water samples and observe the surrounding environment of the project area.

4 Methodology

4.1 Hydrocensus

The Hydrocensus main objective is to record the groundwater data available i.e. counting the number of boreholes if present, recording their names, conditions, coordinates as well as measuring the water levels. This helps to identify the baseline groundwater use and users within the study area. A detailed Hydrocensus was conducted within the project area to obtain a representative population of the boreholes in the area. During the Hydrocensus, all available details of boreholes, conditions and water samples were collected and recorded. The detailed hydrocensus forms are attached in appendix. Below is a hydrocensus summary table of about 35 boreholes encountered during the hydrogeological site assessment. Water samples were collected in 26 of the 35 boreholes.

Various tools were used in collecting the data such as Dip meter, handheld GPS, measuring tape and a bailer. These tools were used on various boreholes on the site. The hand GPS was used to determine the longitudinal, latitude and elevation for each borehole that was being observed. After recording the GPS coordinates, the measuring tape was used in taking all collar height

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measurements of the boreholes. The level meter together with a measuring tape were used in order to get the water levels.

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Table 4-1: Project Hydrocensus table

Project name	Lephalale Coal Concession			Prepared by	Singo Consulting (Pty) Ltd							
Borehole ID	Latitude	Longitude	Hydrocensus date	Diameter(mm)	Static water level(mbgl)	Borehole depth (mbgl)	Sample taken	Current use	Casing	Date drilled	Comments	
HK 01	-23,701022	27,434892	04/09/2020	165	40,37	160,45	Yes	Exploration borehole	Steel	28/07/2020	Light brown water sample, not closed	
HK 02	-23,700059	27,4377	04/09/2020	225	43,95	172,51	yes	Exploration borehole	Steel	21/08/2020	Dark brown to black water sample, Closed with wood, unkept evironment with oils from the drill rig	
HK 03	-23,701022	27,434892	04/09/2020	165	40,07	166,58	yes	Exploration borehole	Steel	03/08/2020	Black water sample with bad odor,	
HK 04	-23,696716	27,43354	05/09/2020	165	38,8	169,51	yes	Exploration borehole	Steel	13/08/2020	Dark brown to black water sample, Closed with wood, unkept evironment with oils from the drill rig	
HK 05	-23,696654	27,4335226	04/09/2020	165	38,34	166,49	yes	Exploration borehole	Steel	31/08/2020	Black water sample with bad odor,	
Percussion BH 1	-23,697953	27,436051	05/09/2020	N/A	Dry	N/A	No	Percussion borehole	None	N/A	Poorly constructed borehole with no casing	
Monitoring BH 1	-23,700341	27,437665	05/09/2020	225	N/A	N/A	No	Groundwater Monitoring Borehole	Steel	N/A	Locked with Key, properly constructed borehole	
SLCC-BH1	-23,702102	27,434382	05/09/2020	225	N/A	N/A	yes	Running water being pumped to the reservoir and used for dust suppression	Steel	2017	Well constructed borehole, which pumps 3000l/h, clear colour water sample was collected	
SLCC-BH2	-23,703065	27,434415	05/09/2020	225	N/A	N/A	yes	Running water being pumped to the reservoir and used for dust suppression snd to water the law	Steel	2017	Well construc ted borehole, which pumps 4500l/h, clear colour water sample was collected	
SLCC-BH3	-23,699771	27,450003	05/09/2020	165	Dry	N/A	No	N/A	Steel	N/A	Old Borehole cased and not closed	
SLCC-BH4	-23,701348	27,457967	05/09/2020	225	53,31	N/A	yes	N/A	Steel	07/2020	This borehole is planned to be used for the wash plant. The water will be pumped into dams and used for the wash plant.	
SLCC-BH5	-23,701288	27,457971	05/09/2020	225	53,65	N/A	yes	N/A	Steel	07/2020	Clear water sample	
SLCC-BH6	-23,701463	27,43671	05/09/2020	N/A	Dry	100	No	N/A	None	08/2020	Poorly constructed borehole with no casing	
SLCC-BH7	-23,694276	27,436858	05/09/2020	N/A	Dry	N/A	No	N/A	None	08/2020	Poorly constructed borehole with no casing	
SLCC-BH8 (Percussion BH)	-23,698159	27,4354	05/09/2020	N/A	Dry	N/A	No	Percussion borehole	None	N/A	Poorly constructed borehole with no casing	
SLCC-BH9	-23,707163	27,450647	05/09/2020	N/A	N/A	N/A	yes	Used for farmhouse activities (including drinking water)	Steel	N/A	Well constructed borehole, clear colour water sample was collected	
SLCC-BH10	-23,656225	27,412029	05/09/2020	225	31,26	N/A	yes	N/A	Steel	N/A	Well constructed borehole, brackish colour water sample was collected, closed and cased.	
SLCC-Reservoir	-23,703065	27,434415	05/09/2020	255	N/A	N/A	yes	Borehole water pumping to borehole	Steel	N/A	Well constructed borehole, clear colour water sample was collected, closed and cased.	
R303712 (Monitoring BH)	-23,673469	27,408699	06/09/2020	165	34,46	N/A	yes	N/A	Steel	N/A	Monitoring borehole, yellowish color water sample	
SLCC-PS306025	-23,66015	27,406389	06/09/2020	225	32,05	N/A	yes	N/A	Steel	N/A	Not in use, cased and not closed	
SLCC-BH11	-23,656253	27,412023	06/09/2020	165	30,52	N/A	yes	N/A	Steel	N/A	Poorly caped, damaged casing, rusted casing, brown water sample	
SLCC-BH12	-23,647627	27,423215	06/09/2020	165	30,5	N/A	yes	N/A	Steel	N/A	Not capped, rusted casing, bad odor water, brown water sample	
SLCC-BH13	-23,63374	27,424219	06/09/2020	165	31,41	N/A	yes	Monitoring borehole	Steel	N/A	Properly constructed borehole, closed with steel casing, light black color water sample	
SLCC-BH14	-23,619397	27,406151	06/09/2020	225	28,6	N/A	yes	N/A	Plastic	N/A	Steel stick out with plastic inner casing, clear color water sample	
SLCC-BH15	-23,639702	27,393785	06/09/2020	165	28,49	N/A	yes	N/A	Plastic	N/A	Steel stick out with plastic inner casing, clear color water sample	
SLCC-BH16 (003)	-23,639717	27,393781	06/09/2020	165	Dry	N/A	No	N/A	Steel	N/A	Dry borehole	
SLCC-BH17	-23,656111	27,402883	06/092020	225	29,01	N/A	yes	N/A	Steel	N/A	Properly constructed borehole, closed with steel casing, clear color water sample	
SLCC-BH18 (053)	-23,656155	27,402878	06/09/2020	165	30,4	N/A	yes	N/A	Steel	N/A	Properly constructed borehole, closed with steel casing, dark brown color water sample	
SLCC-BH19	-23,657963	27,404069	06/09/2020	165	N/A	N/A	yes	Farmhouse borehole	Steel	2018	Clear water sample	
SLCC-BH20	-23,65368	27,416657	07/09/2020	N/A	60	90	yes	Pumped to the reservoir and used at the lodge and the farmhouse.	Steel	N/A	Pumps about 1500l/h to the resrvoir located at the farmhouse	
SLCC-BH21	-23,680182	27,429703	07/09/2020	N/A	60	100	No	Used for animals	Steel	N/A	Pumps about 1000l/h to the tank	
ZAAIMAN-PM3ST001	-23,661866	27,425578	07/09/2020	165	39,15	N/A	Yes	N/A	Steel	N/A	Drilled about 13years ago and current;y not in use. Pumps about 4000l/h. light black color water sample	
PM35T002	-23,6554991	27,421787	07/09/2020	165	30	113	Yes	N/A	Steel	N/A	Clear water, cased and caped, bad odor water sample, pumps about 3000l/h	
SLCC-BH22	-23,647153	27,431541	07/09/2020	165	Dry	N/A	No	Monitoring borehole	Steel	N/A	Dry borehole	
SLCC-BH23	-23,654391	27,416852	07/09/2020	165	N/A	N/A	Yes	Used for irrigation	Steel	Jan-20	Drilled about 8months ago and current;y not in use, was drilled with the intention to be used for irrigation. Pumps about 900l/h. clear color water sample	

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4.2 Geophysical study

From the study conducted in 2011 by Future Flow GPMS cc, A ground magnetic survey was undertaken to assist in locating dykes, faults and deep weathered profiles for the positioning of groundwater monitoring boreholes. Magnetic data was acquired with a Geotron CG-5 magnetometer, with a station spacing of approximately 10 metres.

Traverse positions as well as the magnetic data and graphs are attached in Annexure A. The results confirmed the presence of faults as indicated on the geological map (refer to Figure 4-1), as well as some smaller fault lines not shown on the large scale geological map. The structures generally trend in a west / east direction.

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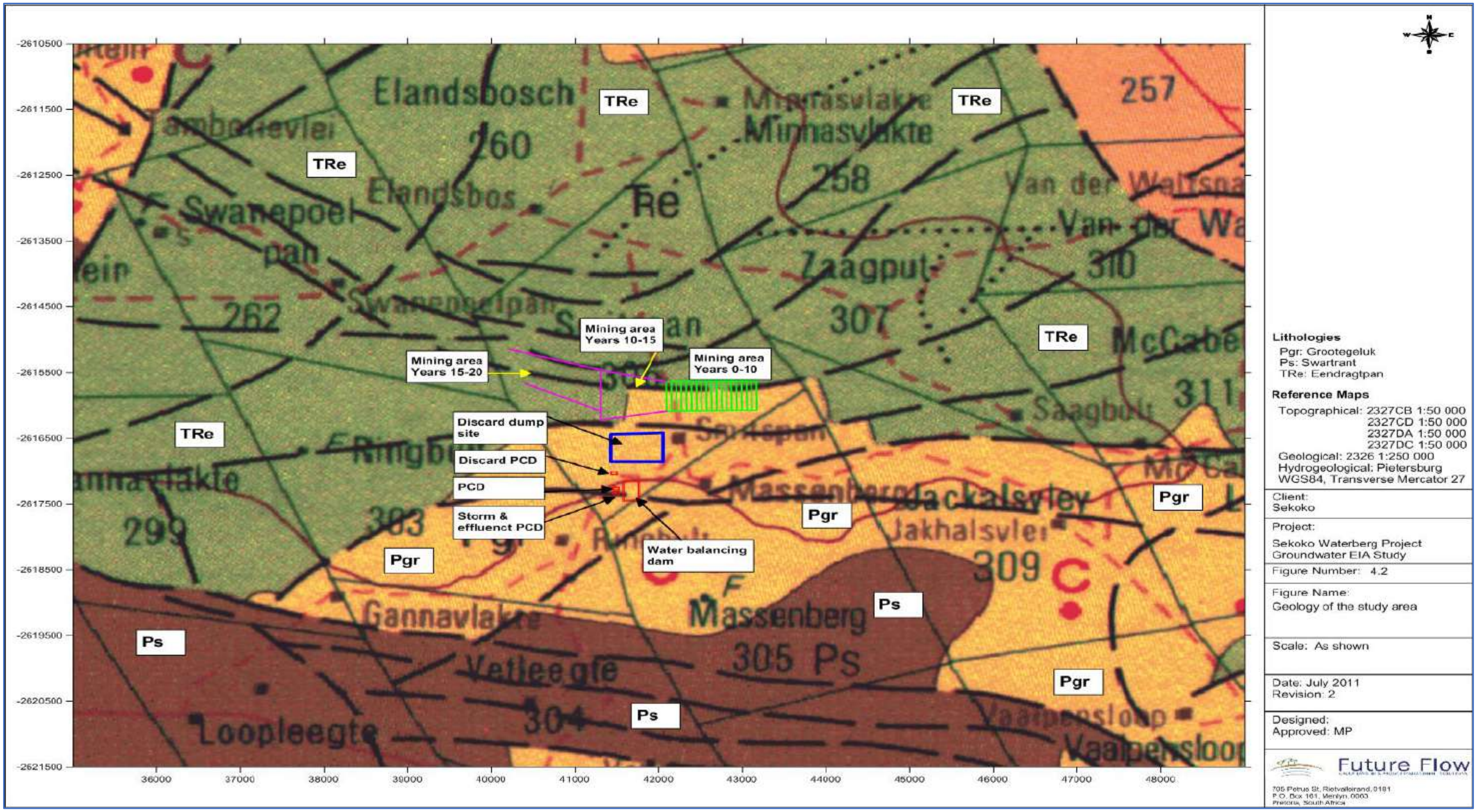

Figure 4-1: Geological map illustrating the presence of faults (Hydrogeological study, 2011 by Future Flow GPMS cc)

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4.3 Drilling and siting of boreholes

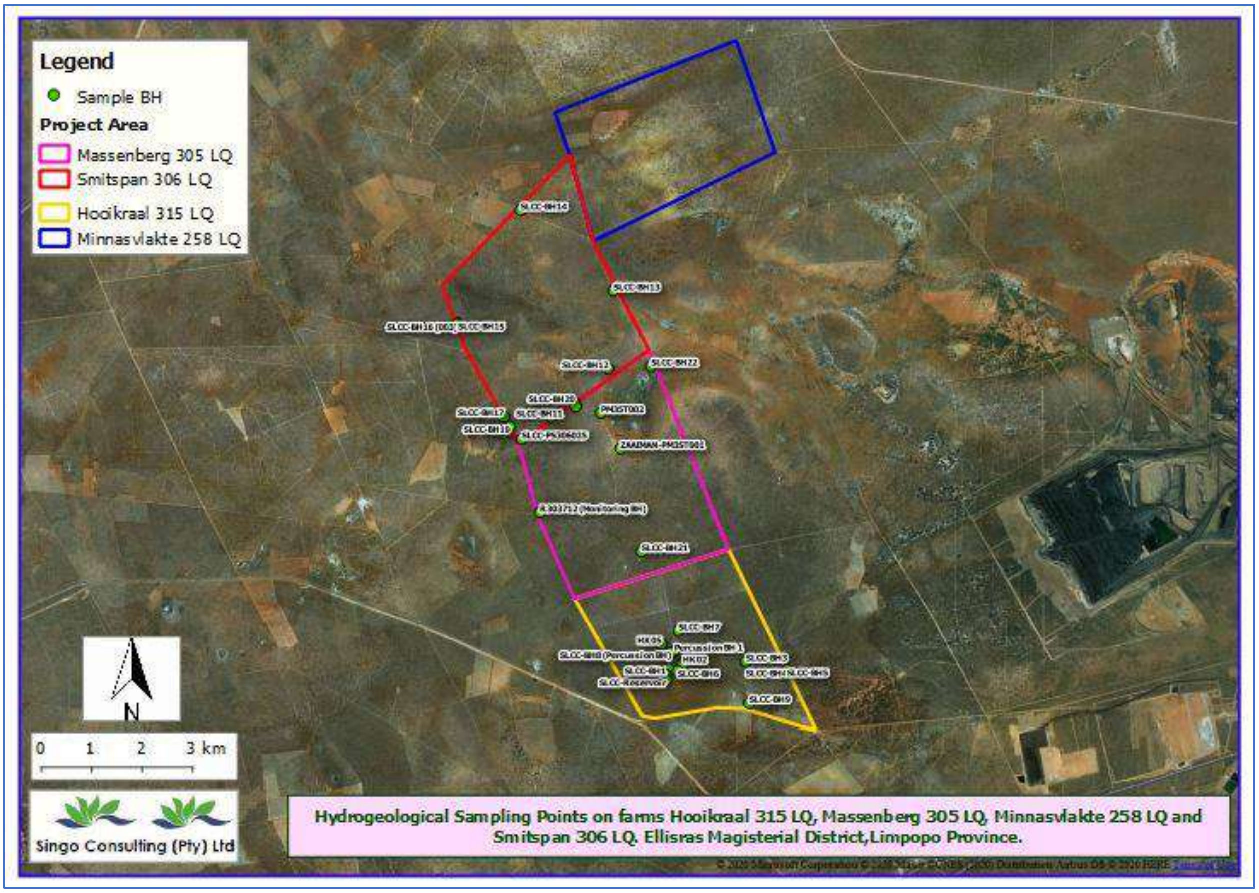

Figure 4-2: Borehole location map

4.4 Sampling and chemical analysis

Chemical analysis

A Piper and Durov diagrams were used to graphically depict the overall composition of the groundwater in the project area based on its major cation and anion composition. To present information on the plots, concentrations in milligrams per litre for major anions and cations are converted to milli-equivalents per litre and then plotted in the lower ternary diagrams to show the percentage contribution of each major ion; one for anions and one for cations. The locations of

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each sample in the anion and cation ternary fields are then projected into the plots. Waters that lie in similar locations in the plots are interpreted to be of the same origin and general composition.

4.5 Groundwater modelling

During model setup, the conceptual model is translated into a numerical model. This stage entails selecting the model domain, defining the model boundary conditions, discretizing the data spatially and over time, defining the initial conditions, selecting the aquifer type, and preparing the model input data. The above conditions together with the input data are used to simulate the groundwater flow in the model domain for pre-mining steady state conditions

Conceptual model

A conceptual model is a simplification of the complex real system down to familiar aspects that can easily be solved. This conceptual model is just a step prior to a solution model which can either be analytical or numerical.

Numerical model

Numerical groundwater modelling consists of flow and transport modelling types. Groundwater flow modelling can be represented by finite difference method or finite element. In this project finite difference method is used. The chosen software is MODFLOW

4.6 Groundwater availability assessment

Fractured Aquifer System

The fractured aquifer system (~ 15 to 40m) present in the fresh rock below the weathered zone are well cemented, and do not allow significant water flow. All groundwater movement therefore occurs along secondary structures such as fractures, cracks and joints in the rock. These structures are best developed in sandstone and quartzite; hence the better water yielding properties of the latter rock type.

Dolerite sills and dykes are generally impermeable to water movement, except in the weathered state. In terms of water quality, the fractured aquifer always contains higher salt loads than the upper weathered aquifer. The higher salt concentrations are attributed to a longer contact time between the water and rock (IGS, 2008).

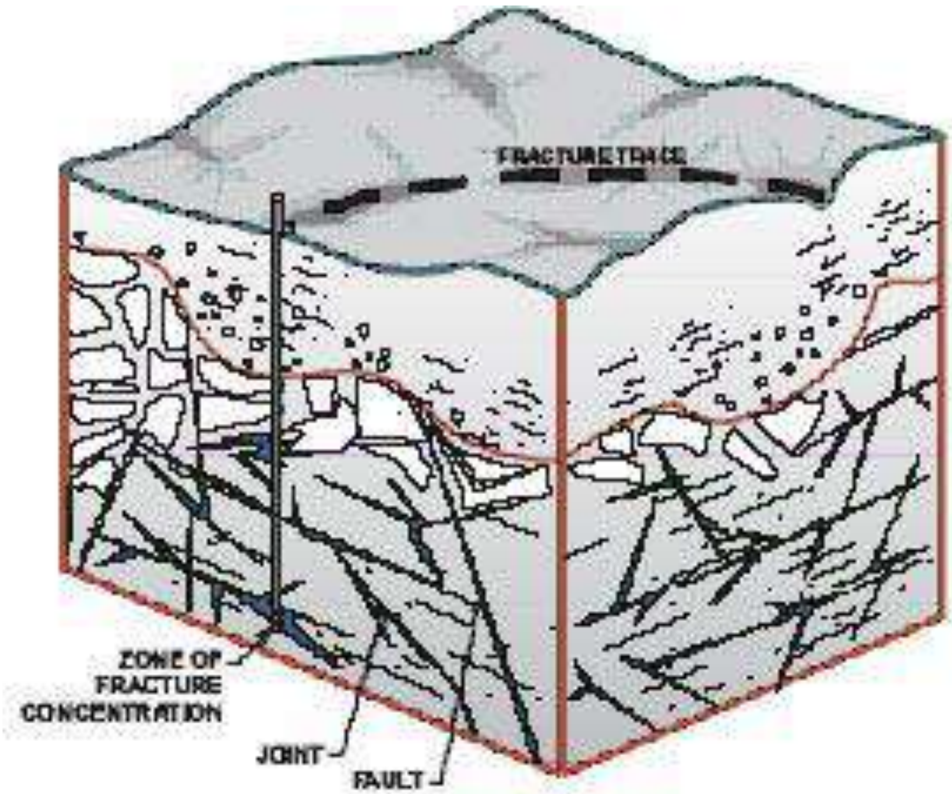

Figure 4- 3: Fractured rock aquifer regime

4.7 Groundwater recharge calculations

Chloride mass balance (CMB)

The method compares total chloride deposition (through precipitation) at the surface with chloride concentrations in groundwater as measured in samples from wells/boreholes. Chloride in the precipitation originates from sea salt. Chloride inputs from atmospheric deposition are conserved in the soil zone and concentrated due to loss of moisture by evapotranspiration.

Chloride ion is often used as a tracer for the investigation of water and solute movement in the unsaturated zone and aquifers. Tracers should be conservative behaviour, i.e. the tracer movement is not slowed or decreased in concentration by interaction with the solid phase and that it is not produced in the soil nor introduced by external sources.

Assumptions:

- All chloride in groundwater is derived from precipitation, no any other sources

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- Chloride is concentrated by evaporation prior to recharge.
- Chloride is conservative in the system
- Runoff after precipitation is negligible (most the precipitation that reaches the ground recharges infiltrates into the unsaturated zone contributing to recharge)

Basic equation for chloride mass balance method (Wood and Sanford, 1995)

$$q = P \times \frac{Clwap}{Clgw}$$

Where:

q is the flux recharge (units of precipitation);

P is the average annual precipitation;

Clwap - is the weight-average chloride concentration in precipitation (a conservative value of 1 mg/l is often assumed) and

Clgw – chloride concentration in the groundwater.

Recharge is often expressed as % of rainfall.

In this project: given data:

Table 4-2: Groundwater Recharge estimation values.

Aspect	**Value**
P	400mm/a (Lephalale)
Clwap	1mg/l
Average recharge of the area	1,996168mm/a

Table 4- 3: Groundwater recharge per borehole

Borehole	**Clgw**	**Recharge (q)**
SLCC - Reservoir	294	1,360544218
SLCC PS 306025	141	2,836879433
Zaaiman PM 3 ST001	177	2,259887006
PM 3ST002	162	2,469135802
Monitoring Borehole R303712	133	3,007518797
SLCC BH 1	267	1,498127341
SLCC BH 2	300,0	1,333333333

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SLCC BH 4	421,0	0,950118765
SLCC BH 5	168,0	2,380952381
SLCC BH 9 (Farmhouse BH)	197,0	2,030456853
SLCC BH 10	305,0	1,31147541
SLCC BH 11	162,0	2,469135802
SLCC BH 12	228,0	1,754385965
SLCC BH 13 (23)	718,0	0,557103064
SLCC BH 14	268,0	1,492537313
SLCC BH 15	152,0	2,631578947
SLCC BH 17	135,0	2,962962963
SLCC BH 18 (053)	159,0	2,51572327
SLCC BH 19	135,0	2,962962963
SLCC BH 20	169,0	2,366863905
SLCC BH 23	164,0	2,43902439
HK 01	151,0	2,649006623
HK 02	295,0	1,355932203
HK 03	282,0	1,418439716
HK 04	254,0	1,57480315
HK 05	305,0	1,31147541

5 Prevailing groundwater

The regional and local geological setting of the area is well documented in the reports by Golder (2018). The project area fall within the 1:250 000 Geological Map series of South Africa Sheet 2326, Ellisras (Council of Geoscience). The description of the regional geological settings of the area is based on the geological description by Günter Brandl (2002). Sediments and volcanics of the Waterberg Group and Karoo Supergroup underlie the study area. Table 5.1 presents the lithostratigraphy of the area.

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Table 5-1: Lithostratigraphy

Age	Supergroup / Group		Formation	Alternative Name	Lithology
Jurassic	Karoo	Stormberg	Letaba	Letaba Formation	Basalt
Triassic			Clarens	Clarens Formation	Fine-grained cream-coloured sandstone
Triassic			Lisbon*	Elliot Formation	Red mudstone and siltstone
Triassic			Greenwich*	Molteno Formation	Red sandstone and conglomerate
Triassic		Beaufort	Eendragtpan*	Beaufort Group	Variegated shale
Permian		Ecca	Grootegeluk*	Upper Ecca Group	Mudstone, carbonaceous shale, coal
Permian			Goedgedacht *	Middle Ecca Group	Gritty mudstone, mudstone, sandstone, coal
Permian			Swartrant*	Lower Ecca Group	Sandstone, gritstone, mudstone, coal
Permian / Carboniferous		Dwyka	Wellington*	Dwyka Group	Mudstone, siltstone, minor grit
Carboniferous			Waterkloof*	Dwyka Group	Diamictite, mudstone
Mokolian	Waterberg		Mogalakwena	Mogalakwena Fm	Coarse-grained purplish brown sandstone

5.1.1 Regional geology

The Waterberg Coalfield is composed of sediments of the Karoo Supergroup and forms a graben structure, bound in the north by the Zoetfontein fault and in the south by the Eenzaamheid fault. The Zoetfontein fault resulted from pre-/during Karoo depositional tectonism, whilst the Eenzaamheid and Daarby faults resulted from post-Karoo depositional tectonism. All the units of the Karoo Supergroup are present in this coalfield, and the subdivision of the Karoo sequence is mainly based on lithological boundaries, consisting, from top to bottom, of the Stormberg Group

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(Letaba), followed by the Beaufort Group, the Ecca Group and the Dwyka Group. The Waterberg Group represents the basin depositional floor, which is mainly composed of the Paleoproterozoic (mokolian) quartzite, arkoses and conglomerates. Regionally, the Waterberg sediments rest on the rocks of the Transvaal Sequence (Golder 2018).

Structural Geology

The Daarby fault is a major northeast, then north-west trending fault, assumed to be part of one set of events, as both legs exhibit the same throw and throw direction. Thus, both faults are combined into one name. The Daarby fault has a down throw of 360m to the north, and the fault dips at an angle of between 50° and 60° to the north. It serves to bring the up-thrown Beaufort and Ecca Groups to the south into contact with the down-thrown Letaba, Clarens, Elliott and Molteno formations to the north (Golder 2018).

The project area is located within the Waterberg Coalfield, which comprises a graben structure with the Eenzaamheid fault forming the southern boundary and the northern boundary is delineated by the Zoetfontein fault. Archaean granite rocks outcrop to the north of the Zoetfontein fault and sediments of the Waterberg Group outcrop to the south of the Eenzaamheid fault. The geological structures can enhance the groundwater potential in the area by increasing the permeability and transmissivity of the host rock. Secondary processes, such as faulting and fracturing, can create secondary fractured rock aquifers.

The Daarby Fault

The Daarby Fault is a major northeast then northwest trending fault, assumed to be a combination of two faults. The down throw (amount of vertical displacement of rocks due to faulting) of 360m to the north serves to bring the Grootegeluk Formation rocks to the south in contact with the younger Clarens Formation sandstone and Letaba Formation basalts in the north. Thus the fault divides the coalfield into a shallow (opencast) coal area to the south of the Daarby Fault, and a deep north coal area. The Daarby fault is impermeable (GCS, 2009)

The Eenzaamheid Fault

The Eenzaamheid fault has a throw of 250m to the north and the fault is near vertical. The fault brings the up thrown Waterberg Group sediments on the south side of the fault in contact with shallow coal on the northern side of the fault. The permeability of the Eenzaamheid fault is not clear, initial groundwater contours indicated that the fault was impermeable and that dewatering at the mine did not impact on the Waterberg Group sediments to the south of the fault.

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Subsequent groundwater modelling (GCS, 2009) indicates that plume migration will occur along the fault, indicating an increased transmissivity along the fault between the two geological units. The Eenzaamheid fault has enhanced groundwater potential and could be targeted for groundwater resource development. The fault can also act as a preferential flow path for groundwater and potential contamination. Any possible contaminant sources should not be constructed on the fault as the fault would facilitate the migration of contaminants off site, which could possibly impact on surrounding groundwater users.

Coal reserves in SA are hosted in sediments of the Permian age which overlie a large area of the country. The coalfields are generally spread over an area of 700 km from north to south and 500 km from east to west.

The Waterberg Coalfield, located in the Waterberg basin, is situated in the north-western part of Limpopo province Figure 5-1. It trends east-west and is characterised by faults, which strike east-west. Such faults are somewhat responsible for the deep occurrence of coal in some areas, which is the reason why those particular areas have been deemed unmineable. This is in contrast with the majority of South Africa's coal deposits, particularly in the Witbank Highveld coalfields, which are relatively shallow with thick seams and are thus easier and usually cheaper to mine.

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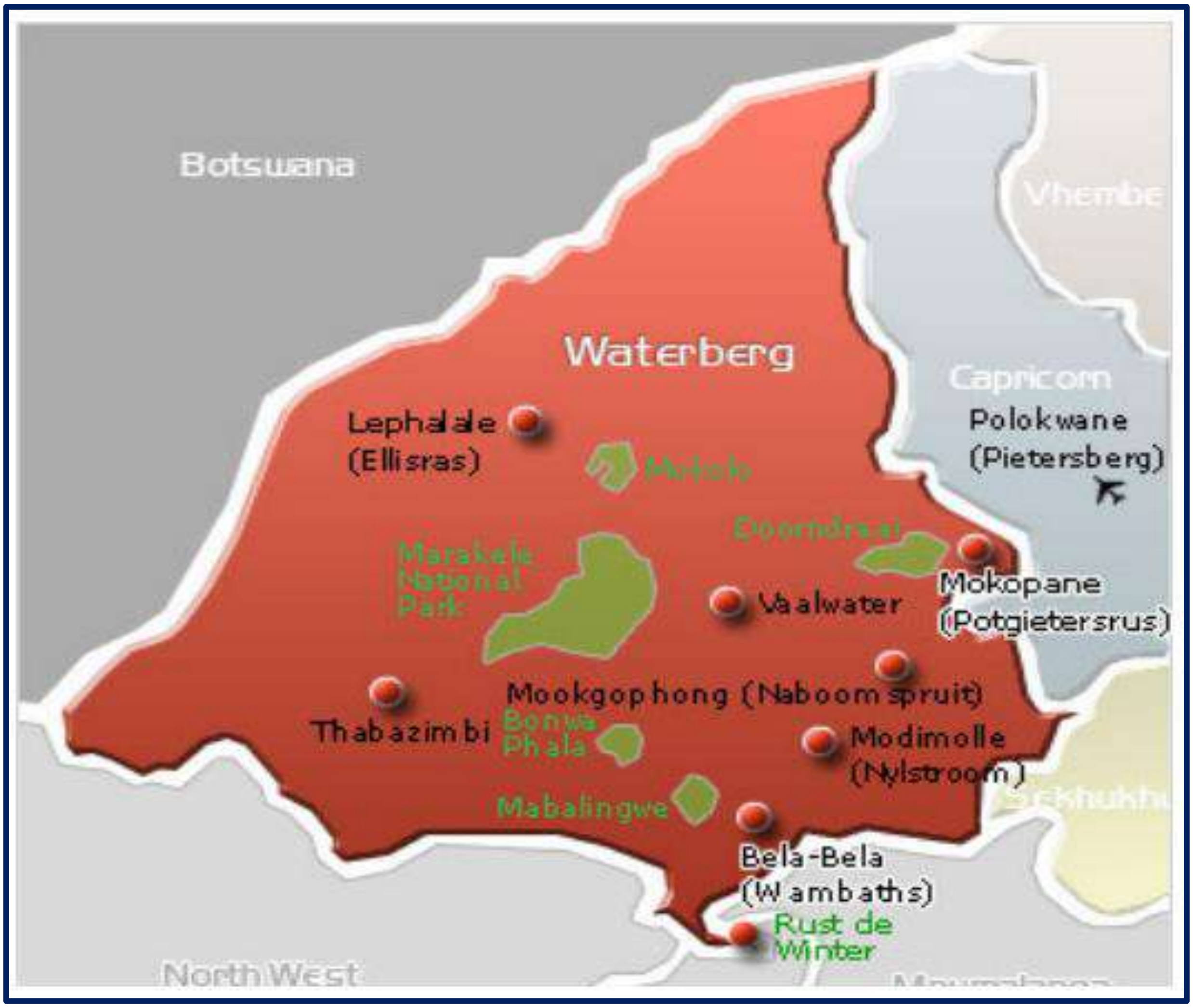

Figure 5-1: Location of the Waterberg coalfield

5.1.2 Local geology

The local geology of the area can be subdivided into two types, which are Karoo sediments and Waterberg sandstone, just south of the Eenzaamheid fault. The sediments of the Waterberg Group (sili-clastic red bed successions) underlie the project area. This is part of the up-thrown sediments comprising the fining upward conglomerate, quartzite facies assemblages of the Mogalakwena Formation. The Waterberg sediments are somewhat re-crystallised and fully oxidized; hence the hardness and red colour of the rock. A thin but permeable layer of sandy topsoil overlies it (Golder, 2018).

As illustrated in the geological map, this area is covered by Alldays Gneiss, Clarens formation and the Karoo sediments. This map serves as a desktop study confirmation of the regional geology of this area which was discussed above. Alldays gneissis of the Randian-age associated with Limpopo belt is categorized as Tonalitic gneiss.

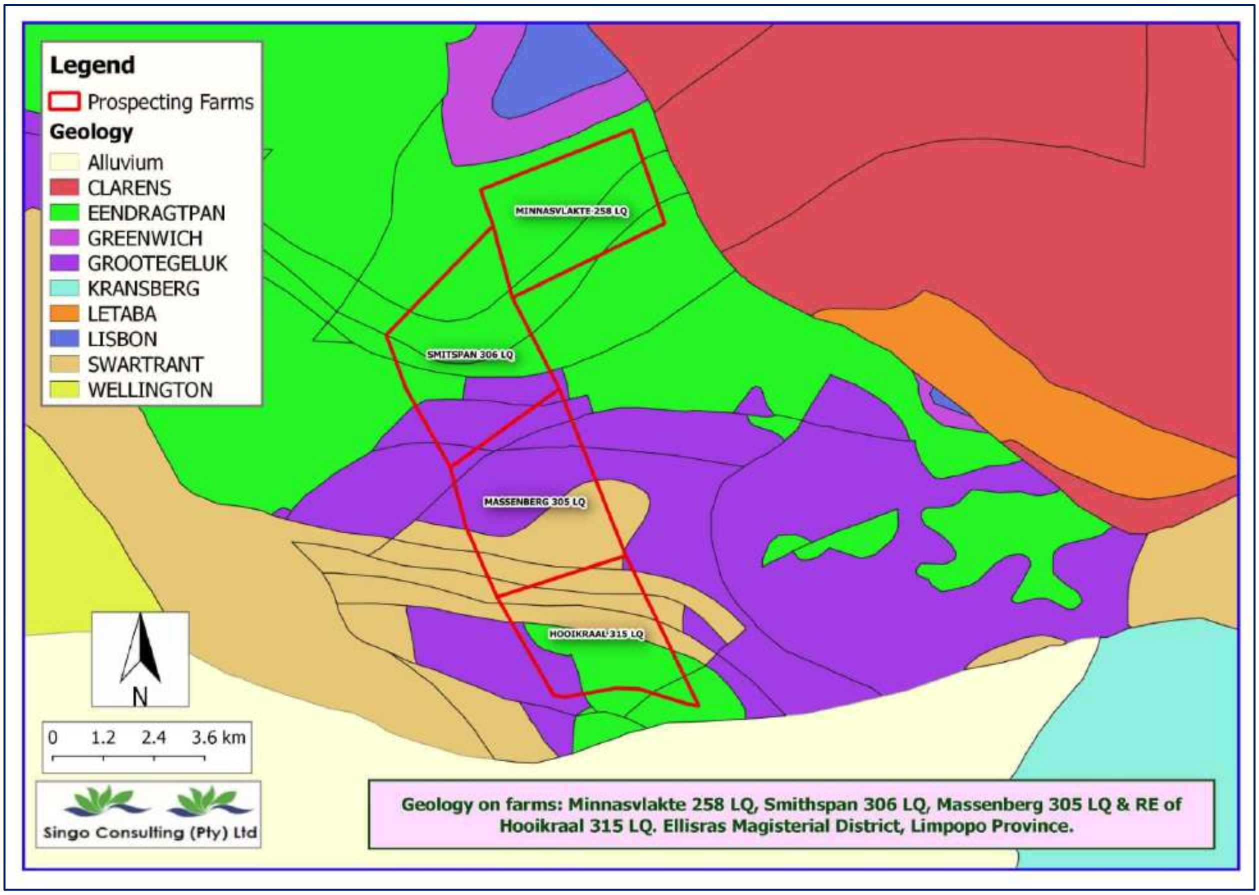

Figure 5- 2: Geological map of the project area

5.2 Acid generation capacity

5.2.1 Acid mine drainage

Acid mine drainage (AMD) is a serious problem in mines where sulphate is a by-product, like in this project where it is a coal mine, AMD is expected to occur due to the extraction of sulphide ores such as chalcopyrite, pyrite or arsenopyrite ores. Therefore, acid mine drainage studies should be included as one of the impacts to be mitigated in this area. Acid mine drainage occurrence in a mining area will be indicated by a **decrease** in pH. The equations below show the process of acid

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mine drainage formation detailed in four steps. This process is self-propagating until the ferric iron or pyrite is depleted. Generally, when pyrite combines with oxygen and water, acid mine drainage forms. Acid mine drainage is dangerous and can destroy aquatic life as well as the aesthetic conditions of a particular environment.

1. Oxidation of Polysulfide to sulphate by O_2

$2FeS_2 + 7O_2 + 2H_2O \rightarrow 2Fe^{2+} + 4SO_4^{2-} + H^+$

2. Oxidation of Fe^{2+} (ferrousiron) to Fe^{3+} (ferriciron) by O_2

$4Fe^{2+} + O_2 + 4H^+ \rightarrow 4Fe^{3+} + 2H_2O$

3. Hydrolysis of iron (ferriciron→ferrichyfroxide, "yellowboy")

$4Fe^{3+} + 12H_2O \rightarrow 4Fe(OH)_3 + 12H^+$

4. Oxidation of polysulfide to sulphate by Fe^{3+} at low pH

$FeS_2 + 14Fe^{3+} + 8H_2O \rightarrow 15Fe^{2+} + 16H^+$

Total: $FeS_2 + 15/4\, O_2 + 7/2\, H_2O \rightarrow 2Fe(OH)_3 + 2SO_4^{2-} + 4H^+$

Acid mine drainage can be treated in various ways including:

- An increase in pH or raising alkalinity. This can be achieved by neutralisation reactions, introducing alkalinity reagents such as Na CO_3 or NaCl,
- Removing metals like iron, zinc and aluminium from water.
- Conducting passive treatments of acid mine drainage (limestone leach beds) as well as conducting active treatment of acid mine drainage (treatment plants)

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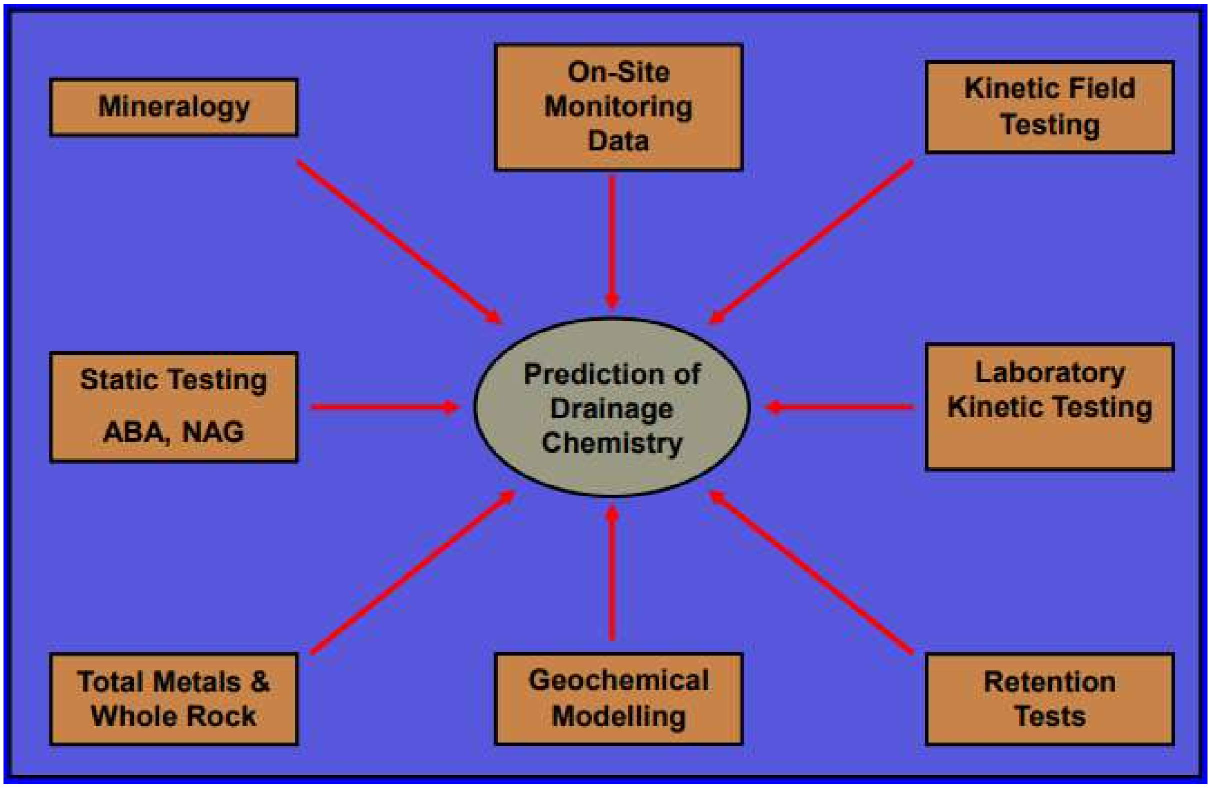

Figure 5-3: The prediction wheel for mine drainage chemistry and the part of ABA (Morin &Hutt,1999; Usher et al.,2003)

5.2.2 Acid base accounting

This section is extracted from the hydrogeological study conducted for Lephalale Coal Concessions in 2011 by Future Flow GPMS cc, this section should be seen as a preliminary assessment of the potential contaminant source and possible formation of acid mine drainage conditions. This is a very important issue, as it is believed that the mine, as any coal mine, could potentially produce acid mine drainage that will impact on the surrounding groundwater quality.

ABA and leach testing

ABA and leach testing were performed on 5 samples from the roof, floor and coal seam material. ABA testing results show that the coal seam has a high acid producing potential. Chemical reactions associated with oxidation of the shale and carbonaceous shale from the roof and floor material is not expected to result in the formation of acid conditions.

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Leach testing show that in general conditions only manganese, iron, fluoride, aluminium, and mercury concentrations will be slightly elevated in the post mining environment. In general it can be said that the long term quality of seepage from the mined-out area will not pose a significant risk to the surrounding aquifers in terms of human consumption

South African coal deposits are associated with sulphide minerals such as pyrite. Sulphide minerals are geochemically inherently unstable and will, in the presence of oxygen, spontaneously begin to oxidise to produce undesirable effects such as a low pH, high sulphate concentrations, and significant increases in heavy metals and radionuclide contents. The acidic water produced by pyrite oxidation can be neutralised when it comes into contact with base minerals such as carbonates, hydroxides, oxides and silicates. The potential of the coal and discard products to produce acid and the subsequent buffering capacity is referred to as the Acid Base Potential. Acid Base Accounting (ABA) provides an average of this process over a period of time, during which either acidic or alkaline conditions can dominate.

ABA involves a combined measurement of sulphur contents (total sulphur, sulphuric acid sulphur, organic sulphur), neutralisation capacity (NP), paste pH and the calculation of acid potential (AP), net neutralisation potential (NNP) and NP/AP ratio (NPR). The assessment obtained by ABA techniques needs to be refined and calibrated with detailed mineralogical characterisation, site-specific observation and kinetic testing. This assessment should be complimented by geochemical modelling in order to increase the reliability of the ARD prediction study.

ABA tests have been performed on five samples as follows:

- BH1H (hanging wall, borehole PS306M01)
- BH1C (coal seam, borehole PS306M01)
- BH2H (hanging wall, borehole PM305M01)
- BH2C (coal seam, borehole PM305M01)
- BH2F (foot wall, borehole PM305M01)

The samples represent all lithologies which are expected to be potentially acid producing, namely carbonaceous shale and sandstones from the roof and floor material, as well as the coal seam itself. It is considered that the sandy weathered zone material, as well as the non-carbonaceous sandstone will not have an acid forming potential due to the inherent chemical nature of the material (mostly silica). The data is summarized in Table 5- 2.

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Based on the available geological descriptions it is considered that the sampled ore body is relatively homogenous with no major compartmentalisation that could lead to chemical differentiation. While the number of samples is limited, it is considered that some representivity of the general mining area and ore body is obtained.

Table 5- 2: Acid base accounting results

Sample ID	Lithology	Neutralising Potential	Acid Potential	Net Neutralizing Potential	NPR
		t per 1000t $CaCO_3$	t per 1000t $CaCO_3$	t per 1000t $CaCO_3$	
		(NP)	(AP)	(NNP)	(NP/AP)
BH 1H	Shale	24.8	0.03	24.8	826.67
BH 1C	Coal	8.90	52.3	-43.40	0.17
BH 2H	Shale	102	0.06	102	1700.00
BH 2C	Coal	8.4	12.7	-4.30	0.66
BH 2F	Carbonaceous shale	32.1	0.48	31.26	66.88

With reference to Table 5- 2 **it must be noted that:**

- NNP - Greater than 5 kg CaCO3/tonne = Alkaline drainage
- NNP - Less than or equal to zero = Acidic drainage
- NNP - Zero to 5 kg CaCO3/tonne = Grey area - prediction is difficult

It can be concluded from these preliminary tests that the coal seam has high acid producing potential. Chemical reactions associated with oxidation of the shale and carbonaceous shale from the roof and floor material is not expected to result in the formation of acid conditions.

Leach testing performed on the rock samples provides an indication of the expected quality of seepage from the mined-out area in the long term. The results are summarised in Table 5- 2. The expected qualities are compared to the SANS241 domestic use quality guidelines.

The results show that in general conditions only manganese, iron, fluoride, aluminium, and mercury concentrations will be slightly elevated in the post mining environment. Although there are no standards for barium, the expected concentrations (ranging between 1 148 and 10 129 µg/l) is considered to be relatively high. The constituents that are expected to exceed the domestic water quality guidelines are discussed below:

- Manganese: At the general measured concentrations (around 0.1 mg/l) staining and aesthetic impacts may occur. At a concentration of 3.9 mg/l the staining of articles coming

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in contact with the water will be extreme and the water is likely to be aesthetically unacceptable to a large portion of the population. No health effects are expected;

- Iron concentrations of between 0.1 and 1.3 mg/l will have an impact on the taste of the water. Slight health effects can be expected in young children and sensitive individuals at concentrations above 1 mg/l. Excessive ingestion of iron may result in haemochromatosis, wherein tissue damage occurs as a consequence of iron accumulation. The extreme unpalatability of such water would probably prevent consumption. Further, iron in the distribution system promotes proliferation of iron-oxidising bacteria which oxidise ferrous iron to ferric iron, and manifest as slimy coatings in plumbing when the iron concentration of the water in the distribution system approaches 0.3 mg/l. The only associated health effects are those that could arise from the presence of microbial deposits on internal surfaces of plumbing;
- Fluoride: Increase concentrations were measured in the BH1C sample. Slight mottling of dental enamel might occur at concentrations between 1.0 and 1.5 mg/l. No other health effects are expected;
- Aluminium: The borehole BH1H material show excessively high aluminium concentrations to be expected in the post-mining environment, while BH2H material show slightly elevated concentrations. At concentrations of around 300 µg/l (0.3 mg/l) no health effects are expected. Noticeable discolouring of the water can occur in the presence of iron and manganese. At a concentration of 1 885 µg/l (1.885 mg/l) there may be long-term neurotoxic effects although this correlation has not been proven conclusively. Severe discolouring of the water can be expected in the presence of iron and manganese; and
- Barium: Barium occurs naturally in groundwater. At the measured concentrations no health impacts are expected. Concentrations of around 500 to 600 mg/l are required before there may be an impact on the heart, blood vessels and nerves of the human body.

In general, it can be said that the long-term quality of seepage from the mined-out area will not pose a significant risk to the surrounding aquifers in terms of human consumption.

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5.3 Hydrogeology

5.3.1 Regional hydrogeology

Typically, five distinct aquifer types:

1. Basement (fractured Achaean-Proterozoic igneous/ metamorphic)
2. Hard-rock (e.g. Table Mountain TMG, Waterberg and Natal Groups sandstone; fractured)
3. Karst/ dolomite (dissolution)
4. Karoo (fractured and influenced by dykes)
5. Porous (intergranular Quaternary alluvial, coastal, Aeolian and other surficial unconsolidated deposits)

The study area falls under the **Hard-rock aquifer type**. For effective borehole yields, the boreholes must target the fracture zones in this area.

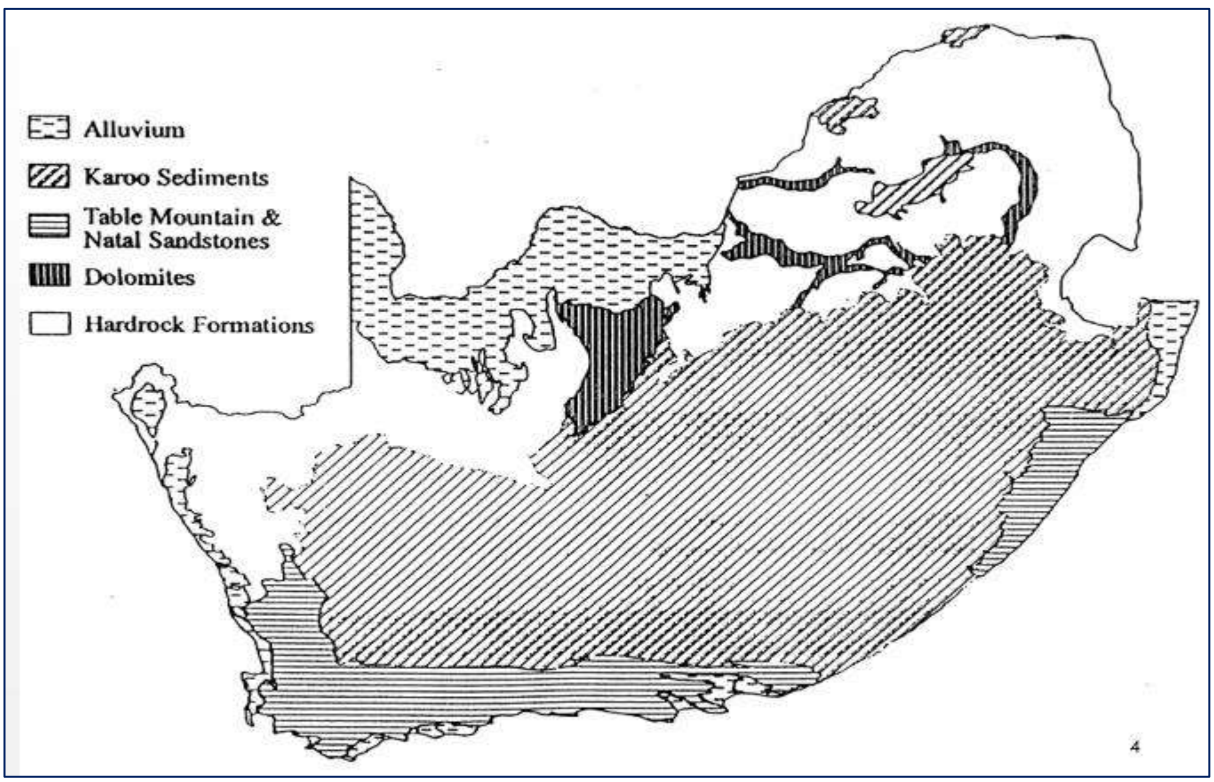

Figure 5-4: Aquifers of South Africa

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The groundwater potential of the formations located in the project area is limited in their pristine state due to low permeability, storage, and transmissivity. Secondary processes, such as weathering, fracturing, etc., are required to enhance the groundwater potential. Based on regional data, as compiled on the 1:500 000 hydrogeological map 2326 Polokwane, the following hydrogeological information is available for the formations on site.

Regional Groundwater Occurrence and Aquifers

Based on the geology within the study area, the structural geology, and the geomorphology, the following conditions can arise to enhance aquifer development within the study area:

- The fractured transition zone between weathered and fresh bedrock
- Fractures along contact zones between the host rocks due to heating and cooling of rocks involved with the intrusions
- Contact zones between sedimentary rocks of different types
- Interbed or bedding plane fracturing
- Openings on discontinuities formed by fracturing
- Faulting due to tectonic forces
- Stratigraphic unconformities
- Zones of deeper weathering
- Fractures related to tensional and decompressional stresses due to off-loading of overlying material
- Groundwater occurs within the joints, bedding planes and along dolerite contacts within the Waterberg Group sediments. Groundwater potential is generally low in these rocks, with 87% of borehole yields < 3 l/s.

The fractured Karoo aquifer consists of the various lithologies of siltstone, shale, sandstone and the coal seams. The pores of the geological units are generally well cemented and the principle flow mechanism is fractured flow along secondary structures e.g. faults, bedding plane fractures etc. The intrusion of the fractured aquifer by dolerite dykes and sills has led to the formation of preferential flow paths along the contacts of these lithologies due to the formation of cooling joints. The dykes may act as permeable or semi-permeable features to impede flow across the dykes.

The fractured pre-Karoo aquifer is separated from the overlying fractured Karoo aquifer by Dwyka tillites which act as an aquiclude where present. The flow mechanism is fracture flow as can be

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expected from the crystalline nature of the granite rocks. The water quality is generally characterised by high fluoride levels which limits exploitation of this aquifer in combination with the general low yields, deep (expensive) drilling and the low recharge (Grobbelaar et al, 2004). Mining of the coal seams has resulted in the introduction of an artificial aquifer system which generally dominates the groundwater flow on a local and regional scale. Below is a summary of the geohydrological system.

Shallow weathered Karoo aquifer (unconfined)

Overburden/Weathered Zone Aquifer

- The weathered zone of the Karoo sediments hosts the unconfined or semi-confined shallow weathered Karoo aquifer. Water levels are often shallow (few meters below ground level) and the water quality good due to direct rainfall recharge and dynamic groundwater flow through the unconfined aquifer in weathered sediments, which makes it also vulnerable to pollution.
- Water intersections in the weathered aquifer are mostly encountered above or at the interface to fresh, where the vertical infiltration of water is typically limited by impermeable layers of weathering products and capillary forces, with subsequent lateral movement following topographical gradients.
- Localised perched aquifers may occur on clay layers or lenses at shallower depth (soil zone), however they are due to their localised and detached nature of no further interest in the context of the current study.
- Alluvial deposits occur in most valley bottoms associated with surface water courses, but their regional coverage is small. These unconsolidated alluvial sediments comprise of clay, sand, gravel and boulder sized grains.

Fractured aquifer

Upper fractured aquifer (unconfined to semi-confined) (less than 70 to 90mbgl)

- The weathered aquifer is underlain by a deeper semi-confined to confined fractured aquifer in which fracture flow dominates. The fractured Karoo aquifer consists of the various lithologies of siltstone, shale, sandstone and the coal seams, where groundwater flow is governed by secondary porosities like faults, fractures, joints, bedding planes or other geological contacts, while the rock matrix itself is considered impermeable.
- Geological structures are generally better developed in competent rocks like sandstone, which subsequently show better water yields than the less competent silt- or mudstones. Not

all secondary structures are water bearing due to e.g. compressional forces from the neo-tectonic stress field overburden closing the apertures.

- Although the Karoo aquifer supports domestic and stock water requirements in the area, their physical and hydraulic characteristics preclude large scale groundwater exploitation for e.g. irrigation.
- The strike frequency analysis for the Karoo rocks indicates a predominant shallow groundwater occurrence, mostly in the first 50 meters below the water table (Woodford and Chevallier, 2002)

5.4 Groundwater levels

During hydrocensus, a dip meter was used to record the groundwater levels for all the boreholes with water within the project farm. The water level is not uniform, and the graph below illustrates the water level recorded in each accessible borehole. The minimum water level is 28,49 mbgl and the maximum water level is 60,00 mbgl.

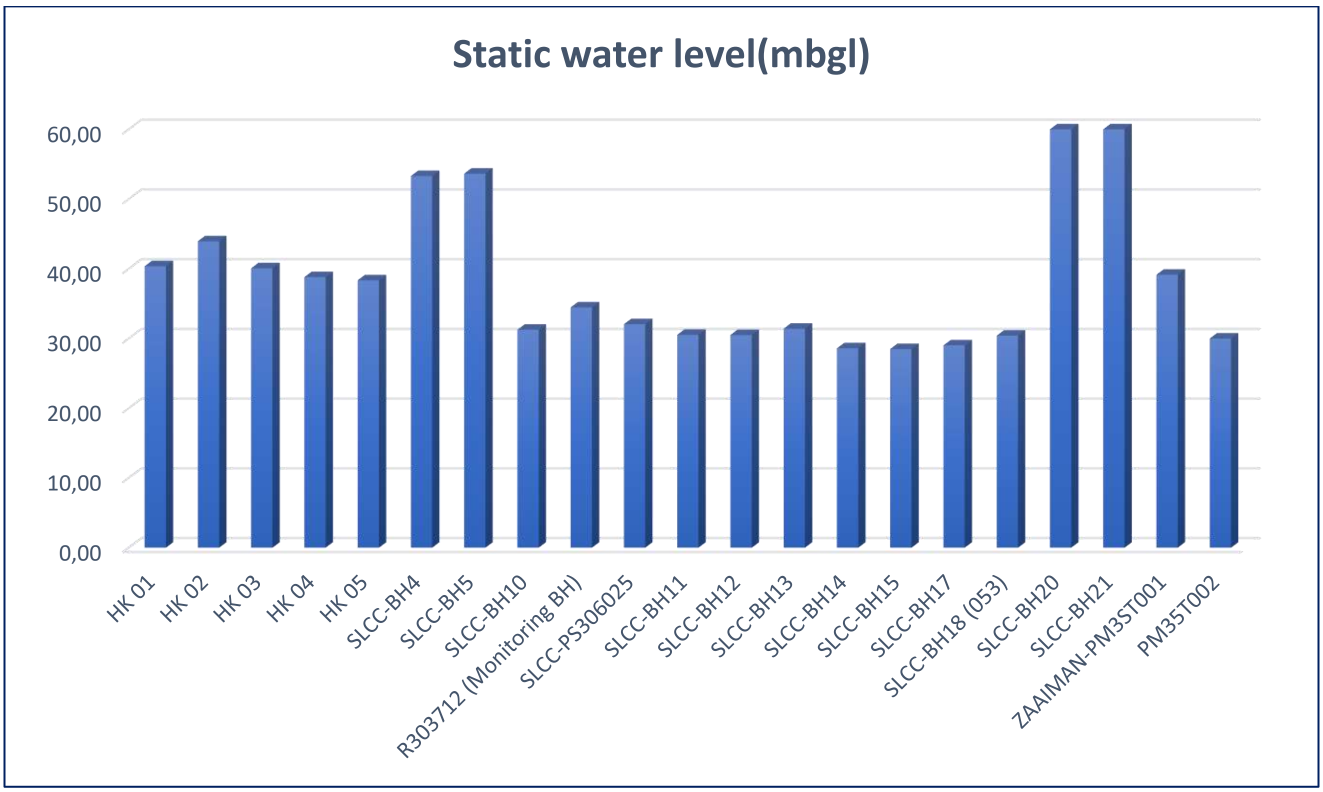

Figure 5-5: Static water level graph

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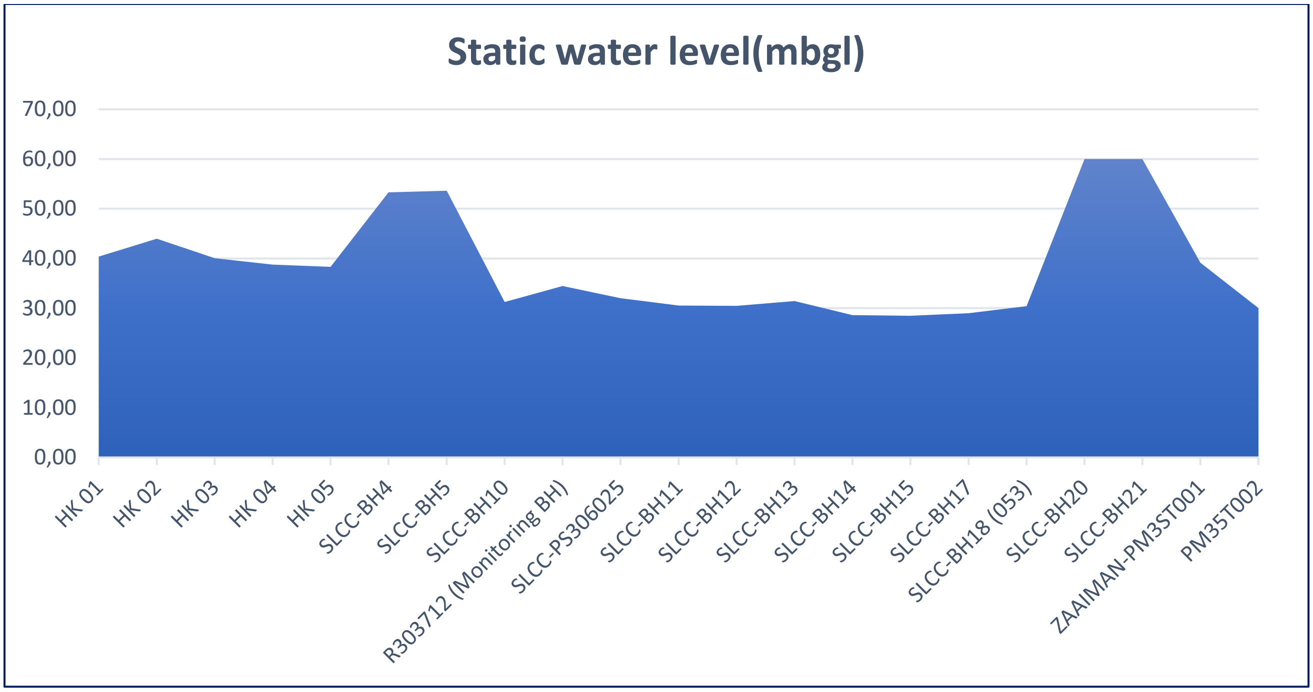

Figure 5-6: Static water level trend analysis diagram.

5.5 Potential Contaminants

The potential contaminants associated with the general area containing the mining right, the product stockpiles, the Briquetting plant and Coal Transfer facility, could be both organic and inorganic: Workshops and fuel and oil handling facilities are likely sources of hydrocarbon related contaminants. Oils, grease and other hydrocarbon products (such as petrol and diesel) handled in these areas may contaminate the environment by spillages and leakages. Oils and greases are removed and collected in oil traps.

Run-off (contained with hydrocarbons) which is not collected may enter the storm water system from where it may contaminate surface water bodies and groundwater. Septic tanks and sewage treatment plants potentially contaminate groundwater. Contaminants associated with these plants include coliforms (e.g. E.coli), bacteria viruses, ammonia, phosphate, sulphate and nitrate. Effluent from these systems usually contains elevated concentrations of organic matter which may lead to elevated COD and BOD. Waste disposal areas may source a wide range of contaminants, ranging from metals, organic matter, hydrocarbons, phosphates, etc.

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Sulphate is probably the most reliable indicator of pollution emanating from coal mining related activities. The chemistry analyses supplied within this report should henceforth serve as baseline water quality throughout the life of the mining right operations

5.6 Groundwater quality

Piper Diagrams illustrates cations and anions shown by separate ternary plots. The apexes of the cation plot are calcium, magnesium and sodium plus potassium cations. The apexes of the anion plot are sulphate, chloride and carbonate plus hydrogen carbonate anions. The two ternary plots are then projected onto a diamond, where the water type is determined.

In this project water samples were collected from boreholes withing the mining right farms and analysed at the Regen waters laboratory whereby the results presented in diagnostic plots below were produced. The piper diagram illustrates the water type available.

<u>Groundwater quality results</u>

On the 04th-7th of September 2020 1st 26 water samples were collected from the available boreholes within the project area and submitted to the Regen Waters laboratory to test for the water chemistry. These water chemistry results are important to know before the authorisation of the water use license.

Data presentation and statistical analysis

- EC values exceeding 75 mS/m will cause the water to have a slightly salty taste but is well tolerated. No health effects are expected at values below 150 mS/m, but the salty taste will become more noticeable with increasing electrical conductivity (EC);
- Iron concentrations in a number of boreholes are elevated. The highest iron concentration recorded is 1.0 mg/l. Iron concentration between 1 and 10 mg/L can have pronounced aesthetic effects as well as problems with plumbing. No health effects are expected at the measured concentrations;
- Chloride concentration between 100 and 200 mg/l has no aesthetic or health effects, with only some increased corrosion of domestic appliances occurring;

In general, it can be said that the groundwater quality does not pose a health risk, although there are some concerns regarding aesthetic aspects described above. The chemical character of the groundwater samples is determined and compared with the aid of a Piper diagram. The Piper diagram, introduced by Arthur Piper in 1944, is one of the most commonly used techniques to

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interpret groundwater chemistry data. This method proposed the plotting of cations and anions on adjacent tri-linear fields with these points then being extrapolated to a central diamond field. Here the chemical character of water, in relation to its environment, could be observed and changes in the quality interpreted. The cation and anion plotting points are derived by computing the percentage equivalents per million for the main diagnostic cations of calcium, magnesium and sodium, and anions chloride, sulphate and bicarbonate.

Different waters from different environments always plot in diagnostic areas. The upper half of the diamond normally contains water of static and dis-ordinate regimes, while the middle area normally indicates an area of dissolution and mixing. The lower triangle of this diamond shape indicates an area of dynamic and co-ordinated regimes. Sodium chloride brines normally plot on the right hand corner of the diamond shape while recently recharge water plots on the left-hand corner of the diamond plot. The top corner normally indicates water contaminated with gypsum (often related to coal and gold mining activities).

In general the top half of the diamond contains static waters and other unusual waters high in magnesium/calcium chloride and calcium/magnesium sulphate. The lower half contains those waters normally found in a dynamic basin environment. Mixtures of any two waters in any proportion plot along a line joining their respective points in each of these diagrams. Water therefore being invaded by an industrial effluent will plot as a vector towards the analysis of the invading fluid.

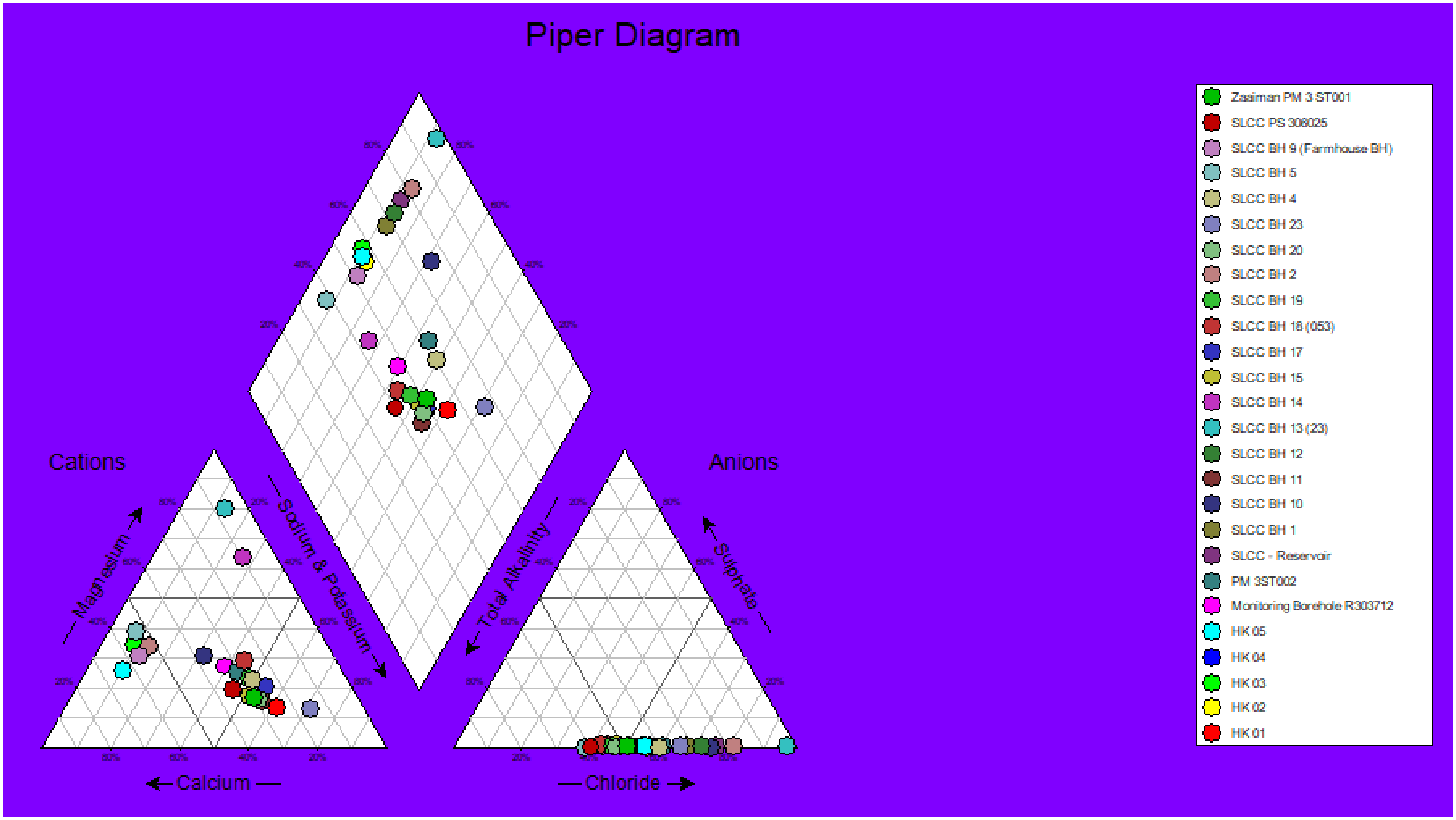

Figure 5-7: Piper diagram illustrating the groundwater type of the project area.

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Table 5-3: Water types interpretation table

Sample	Water Type	PH
SLCC - Reservoir	Calcium/magnesium sulphate chloride water	7,45
SLCC PS 306025	Calcium/magnesium bicarbonate water	7.34
Zaaiman PM 3 ST001	Sodium bicarbonate water	7.97
PM 3ST002	Calcium/magnesium sulphate chloride water	7.08
Monitoring Borehole R303712	Calcium/magnesium bicarbonate water	7.30
SLCC BH 1	Calcium/magnesium sulphate chloride water	7.26
SLCC BH 2	Calcium/magnesium sulphate chloride water	7.26
SLCC BH 4	Calcium/magnesium sulphate chloride water	7.58
SLCC BH 5	Calcium/magnesium bicarbonate water	7.71
SLCC BH 9 (Farmhouse BH)	Calcium/magnesium sulphate chloride water	7.85
SLCC BH 10	Calcium/magnesium sulphate chloride water	6.60
SLCC BH 11	Sodium bicarbonate water	7.43
SLCC BH 12	Calcium/magnesium sulphate chloride water	7.28
SLCC BH 13 (23)	Calcium/magnesium sulphate chloride water	6.90
SLCC BH 14	Calcium/magnesium bicarbonate water	7.61
SLCC BH 15	Sodium bicarbonate water	7.05
SLCC BH 17	Sodium bicarbonate water	6.94
SLCC BH 18 (053)	Calcium/magnesium bicarbonate water	6.86
SLCC BH 19	Sodium sulphate/ chloride water	7.38
SLCC BH 20	Calcium/magnesium bicarbonate water	7.33
SLCC BH 23	Sodium sulphate/ chloride water	6.91
HK 01	Sodium sulphate/ chloride water	6.72
HK 02	Calcium/magnesium sulphate chloride water	8.00
HK 03	Calcium/magnesium sulphate chloride water	8.30
HK 04	254,0	8.47
HK 05	Calcium/magnesium sulphate chloride water	7.55

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Table 5-4: Hydrochemistry results

SiteName	pH	EC mS/m	TDS mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	PALK mg/	MALK mg	Cl mg/l	SO4 mg/l	NO3-N mg	F mg/l	Al mg/l	Fe mg/l	Mn mg/l	NH4_N mg
SLCC - Reservoir	7,45	112	574,00	60.5	29.2	102	12.5	-1,00	126	294	20.3	0,1	0.73	0.02	0.06	0.53	0.39
SLCC PS 306025	7.34	92.5	548,00	37.4	19.9	129	6.89	-1,00	296	141	15.5	0,1	0.49	0.01	0.37	0.39	0.30
Zaaiman PM 3 ST001	7.97	94.0	530,00	67.7	29.7	74.7	9.86	-1,00	243	177	20.1	0,1	1.03	0.01	0.05	0.13	0.24
PM 3ST002	7.08	77.0	434,00	25.8	15.3	103	4.41	-1,00	145,00	162	16.1	0,1	0.53	0.01	0.08	0.22	0.79
Monitoring Borehole R3037	7.30	78.1	436,00	24.8	14.9	116	3.29	-1,00	206	133	24.6	0,1	0.69	0.01	0.56	0.15	<0.20
SLCC BH 1	7.26	114	628,00	67.6	29.0	104	12.0	-1,00	177	267	22.4	0,1	0.77	0.01	0.02	0.55	0.47
SLCC BH 2	7.26	110,0	592,00	57.1	29.8	106,0	13.0	-1,00	94,0	300,0	23.3	0.25	0.45	0.01	0.02	29.8	0.20
SLCC BH 4	7.58	314,0	2556,0	297,0	121,0	357,0	25.1	-1,00	394,0	421,0	1010,0	1.16	0.42	0.04	0.04	121	<0.20
SLCC BH 5	7.71	127,0	808,0	95.1	41.8	118,0	18.2	-1,00	377,0	168,0	140,0	<0.1	1.42	0.22	0.03	41.8	<0.20
SLCC BH 9 (Farmhouse BH)	7.85	106,0	590,0	68.4	28.0	108,0	11.3	-1,00	266,0	197,0	39.5	<0.1	1.50	0.02	0.03	0.10	0.48
SLCC BH 10	6.60	121,0	640,0	47.9	27.0	141,0	5.83	-1,00	141,0	305,0	14.1	<0.1	0.26	0.02	0.61	0.10	<0.20
SLCC BH 11	7.43	96.0	536,0	60.1	25.6	92.5	8.23	-1,00	279,0	162,0	4.91	<0.1	0.72	0.03	0.03	0.26	0.50
SLCC BH 12	7.28	95.7	478,0	11.3	7.34	145,0	27.0	-1,00	122,0	228,0	3.49	<0.1	0.46	<0.01	0.01	0.09	4.83
SLCC BH 13 (23)	6.90	237,0	1298,0	146,0	74.7	176,0	27.3	-1,00	28,0	718,0	3.20	<0.1	0.65	0.02	0.03	0.51	0.53
SLCC BH 14	7.61	204,0	1328,0	115,0	47.6	272,0	20.0	-1,00	490,0	268,0	232,0	15.7	0.43	0.02	0.01	0.03	<0.20
SLCC BH 15	7.05	93.8	546,0	36.6	17.6	128,0	8.00	-1,00	235,0	152,0	42.3	1.05	0.55	0.01	<0.01	0.03	<0.20
SLCC BH 17	6.94	82.4	504,0	21.6	13.8	123,0	7.26	-1,00	198,0	135,0	25.3	1.30	0.37	0.06	0.04	0.01	<0.20
SLCC BH 18 (053)	6.86	98.3	552,0	33.8	20.8	135,0	8.98	-1,00	294,0	159,0	6.61	0.29	0.60	0.01	2.01	0.44	0.54
SLCC BH 19	7.38	84.8	486,0	24.9	14.4	127,0	5.99	-1,00	217,0	135,0	25.0	2.32	0.45	<0.01	0.02	0.02	<0.20
SLCC BH 20	7.33	97.0	526,0	62.8	26.6	91.7	7.91	-1,00	264,0	169,0	19.4	0.21	0.78	0.02	0.01	0.01	<0.20
SLCC BH 23	6.91	76.3	412,0	27.6	15.1	96.1	3.07	-1,00	117,0	164,0	15.7	2.79	0.44	0.01	0.12	0.03	<0.20
HK 01	6.72	80.7	430,0	35.1	17.4	87.7	16.0	-1,00	173,0	151,0	10.9	<0.1	0.57	0.02	0.06	0.31	0.35
HK 02	8.00	140.7	836,0	62.4	25.8	196,0	14.5	-1,00	322,0	295,0	15.2	<0.1	0.82	0.98	1.43	0.97	<0.20
HK 03	8.30	130.6	854,0	87.7	32.3	145,0	18.2	-1,00	298,0	282,0	4.94	0.34	0.85	10.1	10.7	0.55	0.79
HK 04	8.47	131.4	814,0	62.9	26.8	169,0	16.2	-1,00	339,0	254,0	33.4	<0.1	0.83	4.80	3.42	0.56	0.34
HK 05	7.55	134.7	864,0	85.4	28.9	170,0	15.9	-1,00	341,0	305,0	26.4	<0.1	0.80	0.22	0.64	0.64	0.68

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6 Aquifer characterization

6.1 Groundwater vulnerability

Aquifer Systems

Two distinct and superimposed groundwater systems are present in the geological formations of the coalfields in South Africa, as described by Hodgson and Grobbelaar (1999). They are the upper weathered aquifer and the system in the fractured rock below (Golder 2018).

Weathered Aquifer System

The upper aquifer is associated with the weathered horizon. In boreholes, water may often be found at this horizon. The aquifer is recharged by rainfall. Rainfall that infiltrates into the weathered rock reaches impermeable layers of solid rock underneath the weathered zone. Movement of groundwater on top of the solid rock is lateral and in the direction of the surface slope.

This water reappears on surface at fountains, where barriers such as dolerite dykes, paleo-topographic highs in the bedrock obstruct the flow paths, or where the surface topography cuts into the groundwater level at streams, the Waterberg coalfields area is drier than most other coal areas, and the effect will be less significant. It is suggested that less than 60% of the water recharged to the weathered zone eventually emanates in streams (Hodgson and Krantz, 1998). The rest of the water is evapotranspirated or drained by other means (IGS2008).

The weathered zone is generally low yielding, because of its insignificant thickness. Few farmers therefore tap this water by boreholes. The quality of the water is normally excellent and can be attributed to many years of dynamic groundwater flow through the weathered sediments. Leachable salts in this zone have been washed from the system long ago (IGS2008).

Fractured Aquifer System

The fractured aquifer system (~ 15 to 60m) present in the fresh rock below the weathered zone are well cemented, and do not allow significant water flow. All groundwater movement therefore occurs along secondary structures such as fractures, cracks and joints in the rock. These structures are best developed in sandstone and quartzite; hence the better water yielding properties of the latter rock type.

Dolerite sills and dykes are generally impermeable to water movement, except in the weathered state. In terms of water quality, the fractured aquifer always contains higher salt loads than the upper

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weathered aquifer. The higher salt concentrations are attributed to a longer contact time between the water and rock (IGS, 2008)

6.2 Aquifer classification

The figure below illustrates aquifer classification of different areas in South Africa. It can be deduced that the project area comprises of minor aquifers and the dominant water source is surface water.

Table 6-1: Aquifer characterisation

Table 6-1 interprets the meaning of the aquifer classification and when an area is said to have a minor aquifer it means that the aquifer is a moderately yielding aquifer of acceptable quality or high yielding aquifer of poor quality water.

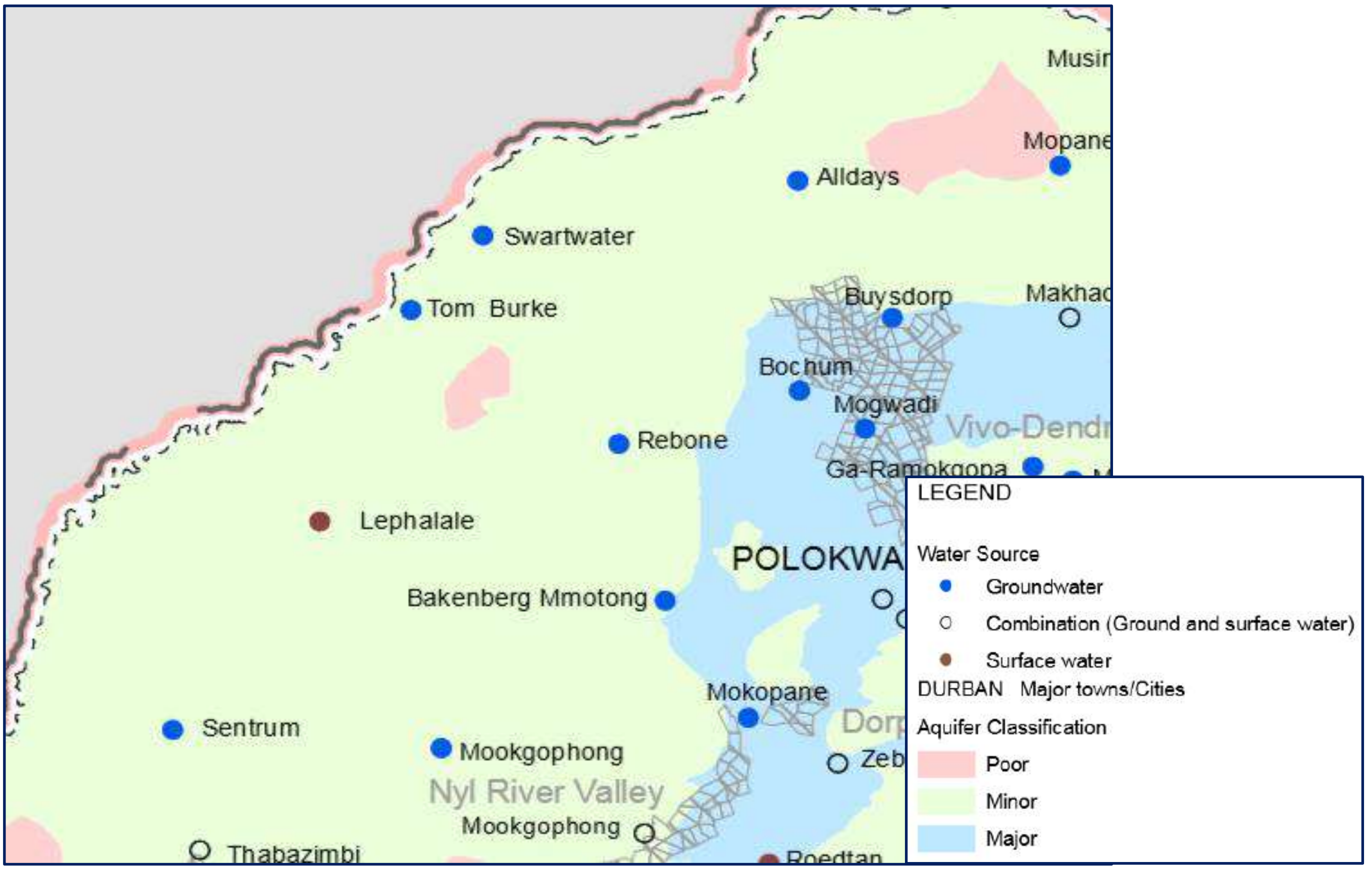

Figure 6-1: Aquifer classification

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Table 6-1: Aquifer characterisation

Aquifer	Description
Sole source aquifer	An aquifer used to supply 50% or more of urban domestic water for a given area, for which there are no reasonably available alternative sources should this aquifer be impacted upon or depleted.
Major aquifer region	High-yielding aquifer of acceptable quality water.
Minor aquifer region	**Moderately yielding aquifer of acceptable quality or high yielding aquifer of poor quality water.**
Poor aquifer region	Insignificantly yielding aquifer of good quality or moderately yielding aquifer of poor quality, or aquifer that will never be utilised for water supply and that will not contaminate other aquifers.
Special aquifer region	An aquifer designated as such by the Minister of Water

Table 6-2: Aquifer protection classification

Aspect	Description
The weathered aquifer	The Ecca sediments are weathered to depths between 5 and 12m below surface throughout the area. The upper aquifer is associated with this weathered zone and water is often found within a few meters below surface. This aquifer is recharged by rainfall The percentage based on work in other parts of the country by Kirchner et al. (1991) and Bredenkamp (1995). It should, however, be emphasised that in a weathered system, such as the Ecca sediments, highly variable recharge values can be found from one area to the next. This is attributed to the composition of the weathered sediments, which range from coarse-grained sand to fine clay. Based on the

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	hydrogeological information obtained from the boreholes drilled at Hendrina, the thickness of the weathered zone was approximated to 15m.
Fractured Ecca Aquifer	The pores within the Ecca sediments are well-cemented and do not allow any significant flow of water. All groundwater movement therefore occurs along secondary structures, such as fractures and joints in the sediments. These structures are better developed in competent rocks, such as sandstone; hence the better water-yielding properties of the latter rock type. It should, however, be emphasised that not all secondary structures are water bearing. Many of these structures are constricted because of compressional forces that act within the earth's crust.
Coal Seam Aquifer	Hodgson et al. (1998) states that of all the unweathered sediments in the Ecca, the coal seams often have the highest hydraulic conductivity. Since the aquifer permeability and storativity of the seam will also be enhanced by mine excavation, it has been simulated as a separate aquifer with an approximate permeability of 0.1m/d. This permeability is in the same order of magnitude estimated for the coal seams by Hodgson et al. (1998).

7 Groundwater Modelling

7.1 Introduction

The following chapter is extracted from the hydrogeological study conducted in 2011 by Future Flow GPMS cc. The numerical flow model was constructed based on the conceptual groundwater flow model discussed above. The numerical model was constructed using MODFLOW based software, which is an internationally developed, recognised and used software package. The model includes all parameters discussed in previous sections of this report and takes into consideration aspects such as:

- The different aquifers present in the area and their interrelation to each other;
- Recharge from rainfall;

- Aquifer transmissivities, effective porosity, vertical hydraulic conductance etc;
- Groundwater flow patterns and velocities;
- Geological lithological units and features such as the extensive faulting that occur in the area; and
- Topographical elevations of surface, the contact between weathered material and competent rock.

The model was calibrated using the "trial-and-error" method where aquifer parameters are varied within realistic ranges until the model is able to reproduce the field specific conditions. For this study the model was calibrated in the steady state using the groundwater level elevations measured during the hydrocensus.

Since there are a multitude of parameters that influence the model calculations there is no unique single solution to the model where an optimum fit can be obtained. Therefore, it is imperative that realistic values be used and the results evaluated to judge whether the obtained groundwater levels and flow patterns are realistic.

7.2 Spatial layout

Normally, numerical model boundaries are selected around natural groundwater flow barriers such as topographical highs and streams that act as groundwater flow divides and barriers. However, due to the physical nature of the study area there are no topographical highs or streams within realistic distances that would still yield an acceptable level of detail in the cell sizes. Therefore, it was decided to construct a square box model with the proposed mining area at the centre. The model extended 6 km to the north, east, south and west of the proposed mining area.

This sizing is based on a theoretical calculation of the maximum zone of influence of mine dewatering. The maximum theoretical zone of influence is calculated using Sichardt's equation:

$$R_i = 3000 D_0 \sqrt{k}$$

Where:

R_i = radius of the zone of influence.

D_0 = maximum drawdown in groundwater level (60 m); and

k = aquifer hydraulic conductivity (ranging from 8.1E-11 m/sec to 4.05E5 m/sec).

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Thus, it can be calculated that the maximum zone of influence using a hydraulic conductivity of 4.05E-6 m/sec is 1 146 m. Thus, it can be concluded that the 6 km (6 000 m) boundary distance is adequate.

A total of two layers were assigned to the model. Each layer depicted a different aquifer:

- Layer 1: The upper aquifer;
- Layer 2: The lower fractured rock aquifer down to 80 m below surface. The mining depth is indicated to be a maximum of 60 m below surface, and there is no information available that confirms that the effective fractured rock aquifer extends deeper than 80 m. Therefore, this depth is deemed acceptable.

7.3 Model grid

The model grid was designed around the delineated model boundary and the proposed development. The highest detail points overlay the proposed development area; with a coarser grid on the far reaches of the model (please refer to Figure 7-1). At the finest the model grid is 25 m x 25 m, while the coarsest grid size is 100 m x 100 m.

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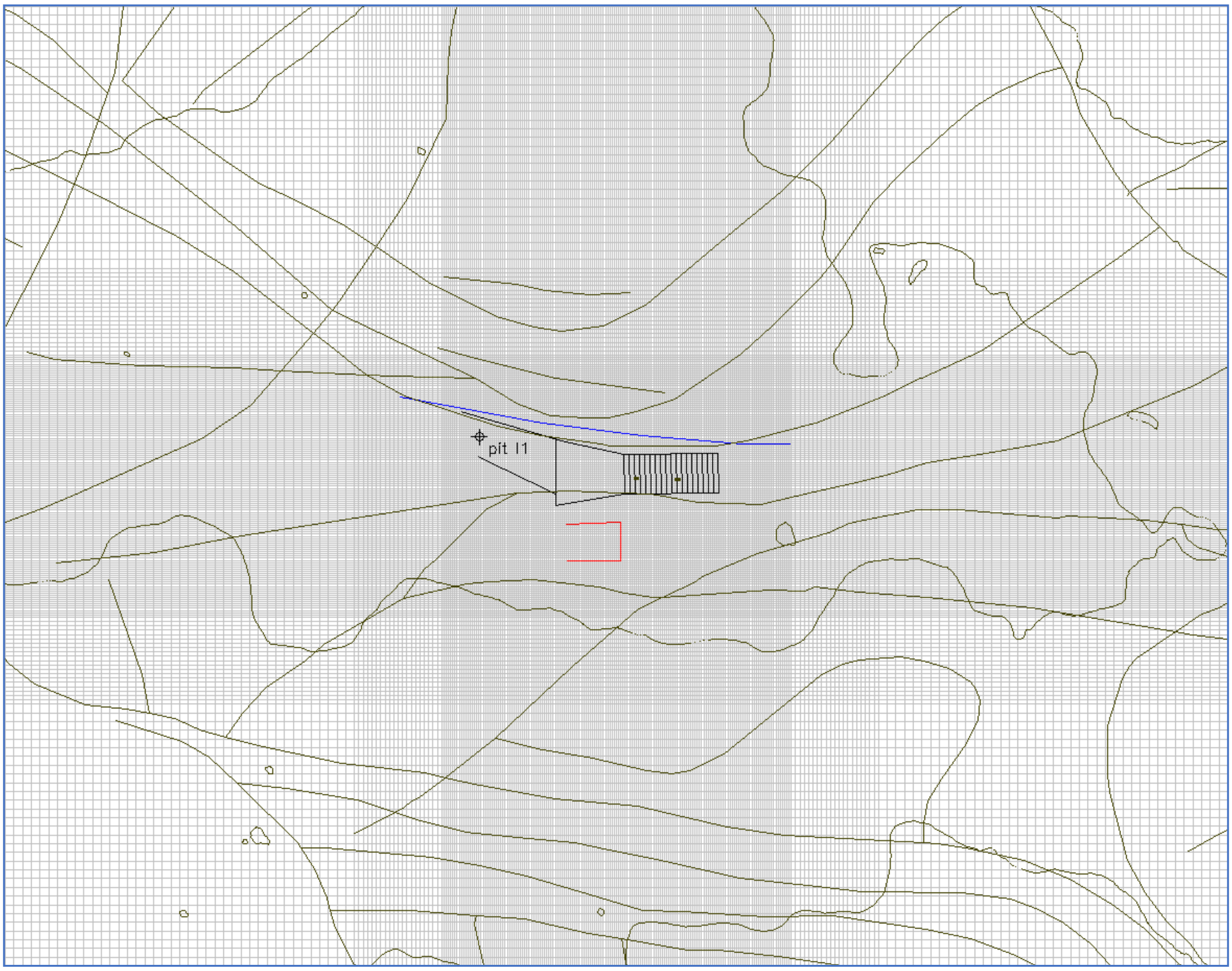

Figure 7-1: Model grid (Future Flow GPMS cc, 2011)

7.4 Layer elevations

The layer elevations were defined as follows:

- Layer 1 top (surface): Topographical elevations obtained from SRTM database;
- Layer 2 top / Layer 1 bottom (contact between weathered material and underlying competent rock): Results from monitoring borehole drilling show an average depth of 15 mbgl. No exploration drilling is available to contour the contact in more detail. Dataset from Layer 1 top minus a constant 15 m value is used;
- Layer 2 bottom (80 m below surface): Dataset from Layer 1 top minus a constant 80 m value is used.

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7.5 Site specific characteristics

- Starting groundwater levels: The starting groundwater levels were extrapolated for the entire model area using the Bayesian method based on the groundwater levels recorded during the hydrocensus;
- Aquifer transmissivities: Aquifer transmissivities were specified using the "transmissivity" package for horizontal transmissivity, and the "vertical hydraulic conductivity" package for the vertical transmissivity. For Layer 2 distinction was made between three zones (please refer to Figure 7-2):
  - General regional geology (indicated in dark blue);
  - General faults (indicated in red); and
  - Faults on geological contacts (indicated in green).
- Perennial streams: No perennial streams exist in the model area;
- Non-perennial streams: No non-perennial streams exist in the model area; and
- Recharge from rainfall: The recharge was applied using the "recharge" package.

7.6 Model sensitivity

Model sensitivity analyses shows that the numerical model is sensitive to:

- Transmissivity of Layer 1 (medium sensitivity);
- Transmissivity of Layer 2:
  - Regional transmissivity (high sensitivity);
  - General faults (medium to high sensitivity);
  - Faults on geological contacts (medium sensitivity); and
- Recharge (highly sensitive).

Based on this it can be deduced that regional transmissivity of the fractured rock aquifer and recharge must be derived to a high level of confidence. Accurate derivation of these values will increase the level of confidence in model outputs.

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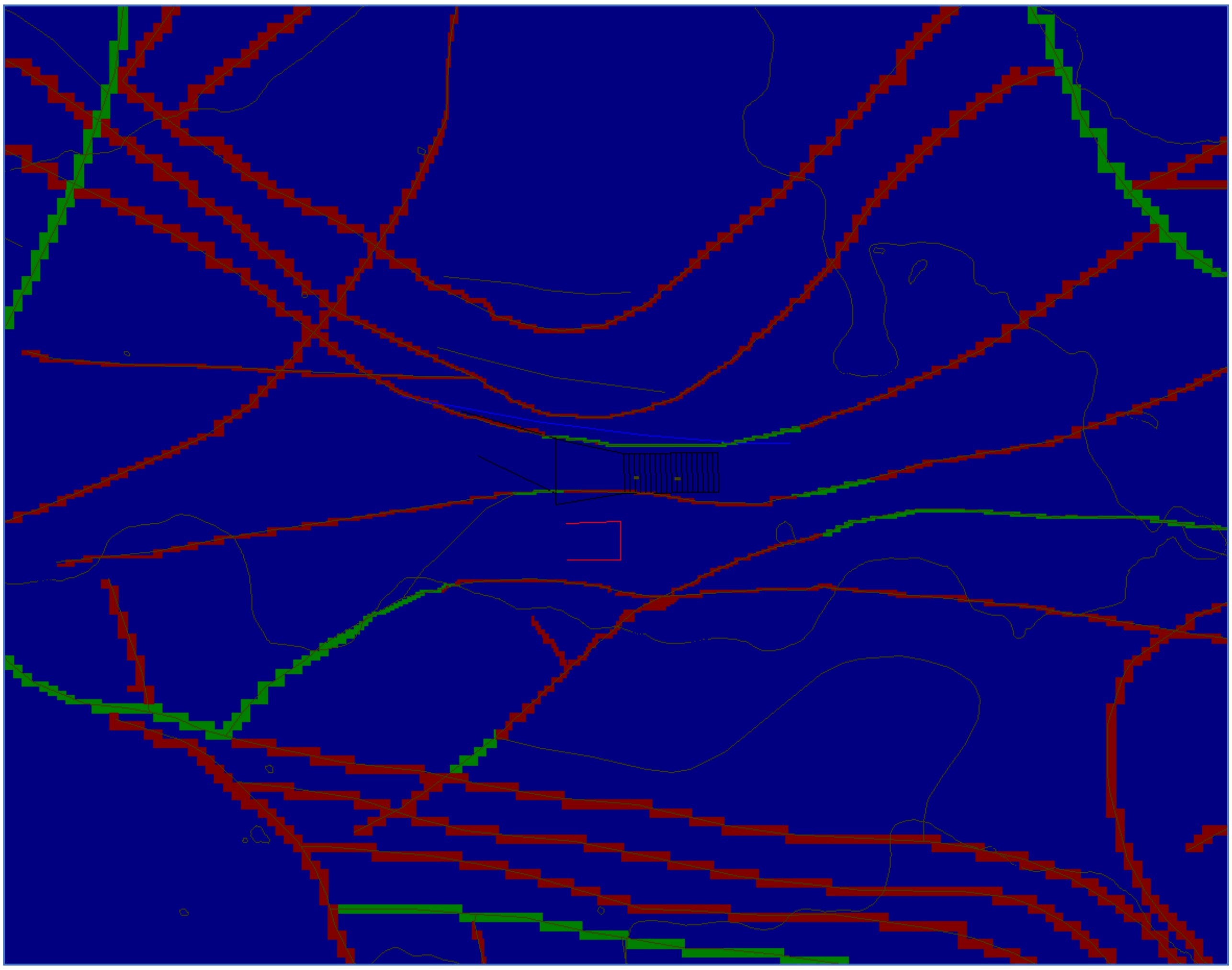

Figure 7-2: Fractured rock transmissivity zones(Hydrogeological study, 2011 by Future Flow GPMS cc)

7.6 Model calibration

As stated above the model was calibrated in the steady state using the "trial-and-error" method where aquifer parameters are varied within realistic ranges until the model is able to reproduce the field specific conditions. For this study there is no long-term monitoring data available and the model was calibrated using the groundwater level elevations measured during the hydrocensus.

The ranges within which the aquifer parameters were varied were derived from the data collected during the desk study and the field work investigation. Aquifer parameter ranges that were used are summarised in Table 7-1.

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Final calibration yielded a variance of 1.24 (please refer to *Figure 7-3*). There was some difficulty obtaining a good fit at some boreholes. However, it has to be stated that the large number of faults in the area, their potential high transmissivity and the fact that their locations are not precisely known makes it difficult to precisely delineate transmissivity zones in the lower aquifer. This affects the calculated water levels at some points.

Table 7-1: Calibrated parameter values(Hydrogeological study, 2011 by Future Flow GPMS cc)

Parameter	**Unit**	**Layer**	**Zone**	**Range**		**Source**	**Calibrated value**
				Minimum	**Maximum**		
Transmissivity	m²/day	1	All	0.8	80	Literature	5
		2	Regional	0.01	2	Aquifer tests	0.5
			General fault	2	30	Aquifer tests	20
			Fault on lithological contact	20	130	Aquifer tests	70
Vertical hydraulic conductivity	m/day	1	All	0.005	0.5	10 % of horizontal conductivity	0.004
		2	All	Does not play a role as this is the bottom layer			
Recharge	m/day	All	All	4.794e-6	1.9178e-5	Calculated	6.13364e-6

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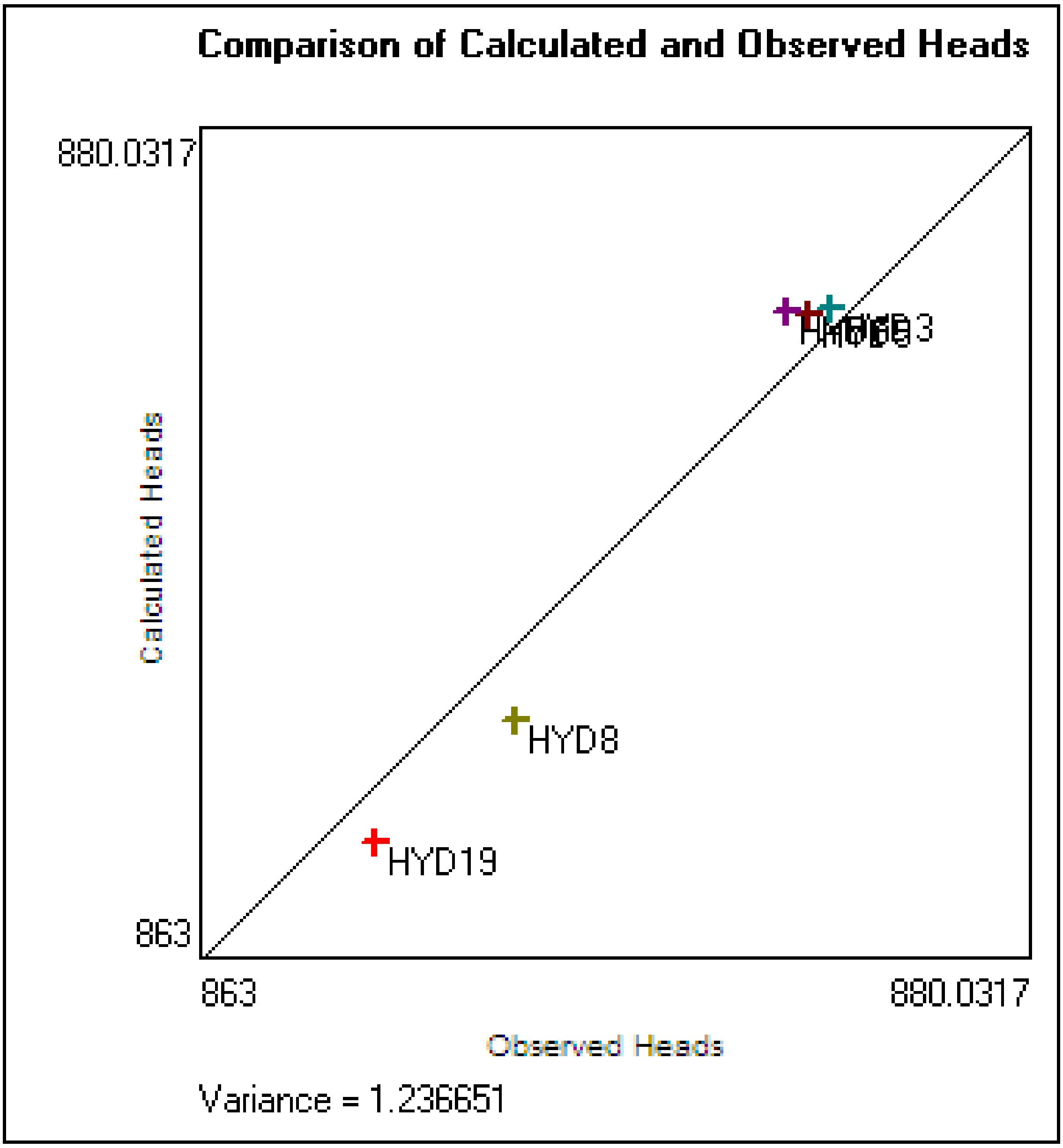

Figure 7-3: Calibration variance(Hydrogeological study, 2011 by Future Flow GPMS cc)

7.8 Model application

The calibrated model was used to simulate the impacts on the surrounding environment from the proposed mining activities. In order to do this the model was adapted:

- The mine progression plan was incorporated into the numerical model. Yearly increments were specified and the inflows into the mine areas were calculated;
- The groundwater inflow volumes and level fluctuations will be impacted by the effect of rehabilitation and the elevated recharge from rainfall that is associated with disturbed and

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rehabilitated areas. Studies done by Hodgson and Krantz show that recharge onto levelled spoils and rehabilitated spoils can be on average 20 % and 8 % of mean annual rainfall respectively. Potential recovery times were simulated using the numerical flow model. The assumptions around recharge include:

- During the first year of rehabilitation the spoils are levelled and a recharge value of 20 % of mean annual rainfall is applied to the newly rehabilitated area;
- It is assumed that a period of 5 years will elapse before rehabilitation is complete, soils have completely settled and vegetation is fully established. A recharge percentage of 8 % of MAR is applied during these years;
- After 5 years of rehabilitation (total of 6 years after an area is mined) it is assumed that the area is settled and recharge to that area is comparable to un-mined areas.

7.9 Contaminant transport model

The development of the contaminant plume away from the discard area was simulated using the 3-D numerical contaminant transport model. Contaminant transport modelling was performed using the MT3DMS package. As discussed in ABA and static leach testing results indicate that the roof and floor material is unlikely to lead to the formation of acid conditions. However, in order to be conservative, it has to be assumed that some coal seam material will be included in the discard dump that can potentially be a source of contamination.

Leach testing shows that no elements will be present in significant concentrations that can lead to health impacts. Therefore, it was decided to apply a generic approach. The results can then be applied to any contaminants that may be identified from further acid base accounting and leach testing. A value of 100 is assigned to the pollution source areas, in this case the discard area. In effect this represents 100 % of the starting concentration of any contamination. The plume distribution then represents the percentage of starting concentration that will be measured at a specific point. For example should the plume at a specific point indicate a value of 50, it indicates that the element concentration at the point and time is expected to be 50 % of the initial source concentration.

Several parameters were specified:

- Initial concentrations: A value of 0 was specified over the whole of the model area;
- Advection: There is no information available on the advective characteristics of the rock material. Therefore, default values were assumed and the upstream finite difference methods was applied, with a default Courant number of 0.75;
- Dispersion: There is no site specific information available on the dispersive characteristics of the rock material. Therefore, default values were used. Horizontal and vertical transverse

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dispersivity of 0.1 was used while the effective molecular diffusion coefficient was assumed to be 0;

- Surface contamination from the discard area was assigned using the "recharge" package where a recharge concentration is specified. A constant concentration value of 100 was assigned during the life of mine under the assumption that continuous deposition of rock material on the discard facility will maintain the source concentration;
- Hodgson and Krantz (1995) found that recharge in discard dumps are artificially increased compared to natural recharge values. They came to the conclusion that recharge from discard areas into the underlying aquifers can be as high as 15 to 20 % of mean annual rainfall (MAR). For the purpose of this study an average recharge value of 15 % of MAR was applied.

Long term post-operational phase

Long term (up to 100 years after mine closure) contaminant migration pathways are simulated using the numerical groundwater flow and contaminant transport models to determine the contaminant migration patterns.

As described in Section of the ABA test results show that the formation of acid mine drainage from roof and floor material is not likely. However, the exposed coal seams in the mined-out area will be subjected to oxidation and therefore it can be expected that some acid mine drainage will form during the early years after mine closure. Once the coal seams are submerged below the recovering groundwater level oxidation and chemical reactions will largely stop.

Coal material contained in the discard dump will also be liable to form AMD conditions. However, over time as the elements are leached from the material the source concentrations will decrease.

Because no data is available on the rate at which elements will be leached from the discard material and rehabilitated opencast mine some assumptions had to be made regarding the source concentrations at the rehabilitated mine area and the discard dump over time:

- Years 0 to 10 after closure: A source concentration of 100 % of original concentration is assumed;
- Years 10 to 20 after closure: A source concentration of 50 % of original concentration is assumed;
- Years 20 to 50 after closure: A source concentration of 25 % of original concentration is assumed; and

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- Years 50 to 100 after closure: A source concentration of 10 % of original concentration is assumed.

The pollution plume at the end of life of mine is used as the starting point for the long-term plume development.

8 Geohydrological impacts

The following chapter includes groundwater level and contaminant models extracted from the hydrogeological study conducted in 2011 by Future Flow GPMS cc. An environmental impact assessment is constructed based on the available information and the 3D numerical groundwater flow and contaminant transport modelling that was done. The model was constructed based on site specific information gathered during the study and calibrated using the groundwater levels measured during the hydrocensus.

8.1 Construction phase

The boxcut will be excavated to a depth of 60 m, breaching the groundwater level. Pit dewatering will be required, leading to the localised dewatering of the aquifer. The zone of influence will not extend more than 400 m from the boxcut and the maximum drawdown in groundwater level in the upper and lower aquifers will be around 40 m in the lower aquifer (Figure 8-1 and Figure 8-2) .

Surface construction of the discard dumps, pollution control dam, haul roads and offices will not breach the groundwater level and is therefore not expected to have any impact on the groundwater levels.

- It is assumed that adherence to general good housekeeping rules with regard to diesel, oil and other potential contaminants will prevent contamination of the aquifers.
- No private groundwater users or surface water bodies will be impacted by the dewatering and associated drawdown cone.
- In general it can be said that the impacts during the construction phase will be localised.

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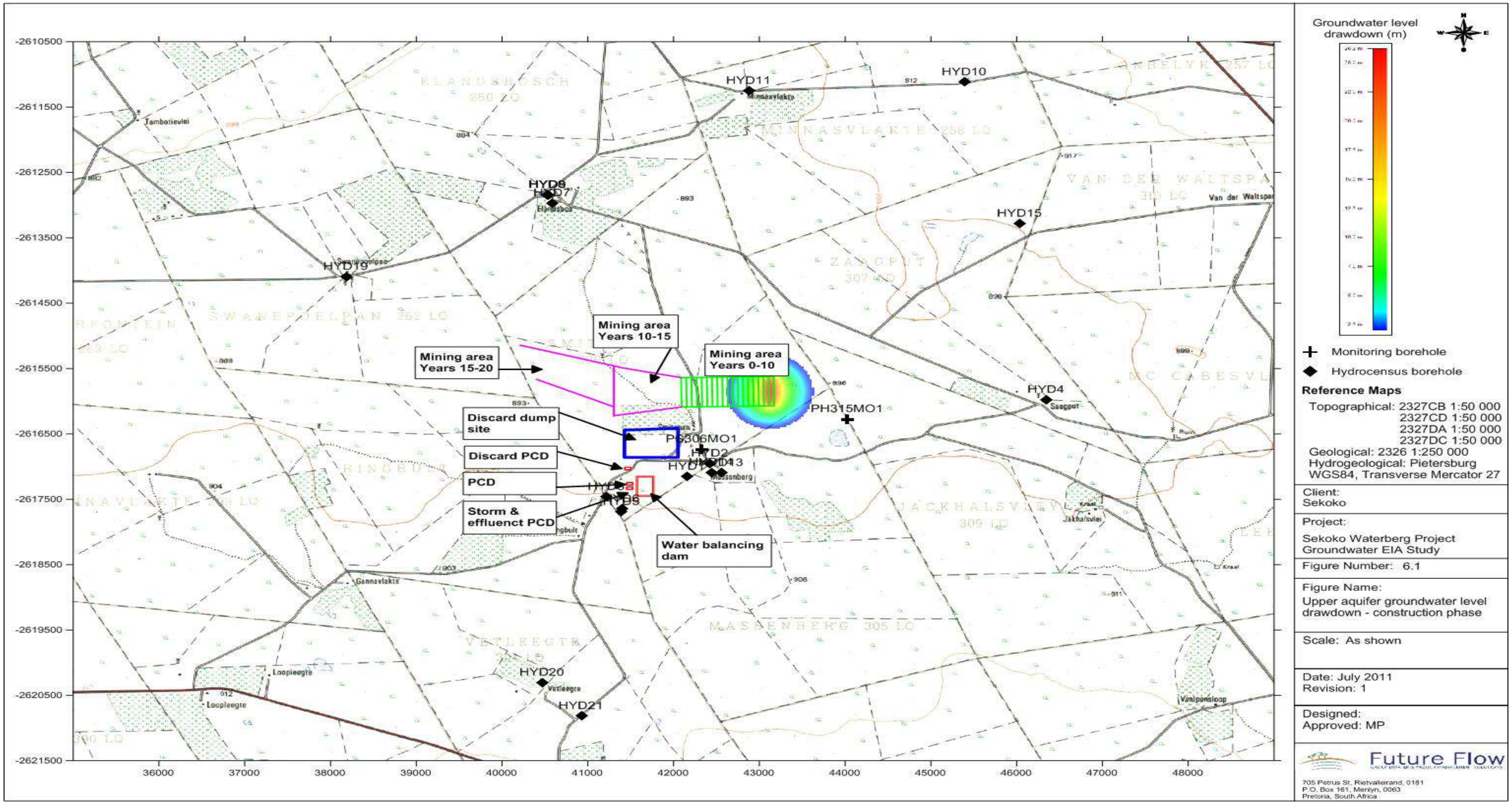

Figure 8-1: Upper aquifer groundwater level drawdown – construction phase(Hydrogeological study, 2011 by Future Flow GPMS cc)

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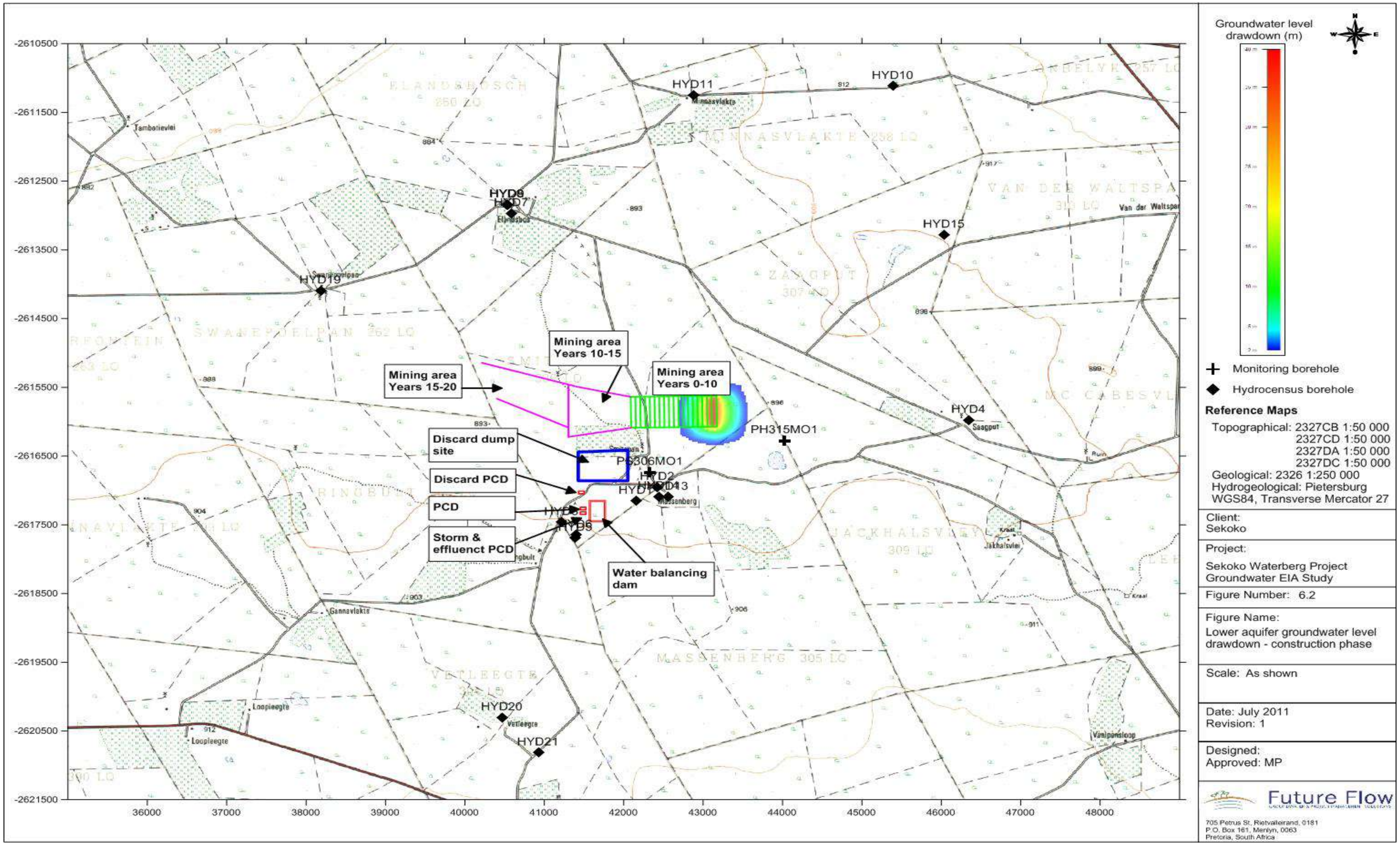

Figure 8-2: Lower aquifer groundwater level drawdown – construction phase(Hydrogeological study, 2011 by Future Flow GPMS cc)

8.2 Operational phase

8.2.1. Groundwater level drawdown and zone of influence

The mine floor elevation is below the general groundwater level thus causing groundwater inflows into the opencast area from the surrounding aquifers during operations. The mining area will have to be actively dewatered to ensure a safe working environment. Pumping water that seeps into the mine area to surface will cause dewatering of the surrounding aquifers and an associated decrease in groundwater level within the zone of influence of the dewatering cone.

The zone of influence of the dewatering cone depends on several factors including the depth of mining below the regional groundwater level, recharge from rainfall to the aquifers, vertical infiltration of the recharging water, the size of the mining area, the aquifer transmissivity, and aquifer storativity amongst others. The 3-D numerical groundwater flow model was used to simulate the development of the drawdown cone over time in the study area.

In addition, the groundwater level fluctuations will be impacted by the effect of rehabilitation and the elevated recharge from rainfall that is associated with disturbed and rehabilitated areas. Studies done by Hodgson and Krantz show that recharge onto levelled spoils and rehabilitated spoils can be on average 20 % and 8 % of mean annual rainfall respectively. Potential recovery times were simulated using the numerical flow model. The assumptions around recharge include:

- During the first year of rehabilitation the spoils are levelled and a recharge value of 20 % of mean annual rainfall is applied to the newly rehabilitated area;
- It is assumed that a period of 5 years will elapse before rehabilitation is complete, soils have completely settled and vegetation is fully established. A recharge percentage of 8 % of MAR is applied during these years;
- After 5 years of rehabilitation (total of 6 years after an area is mined) it is assumed that the area is settled and recharge to that area is comparable to un-mined areas.

8.2.2 Groundwater contamination

The life of mine is planned at 20 years. This allows sufficient time for chemical reactions to take place in the mined-out area, discard dumps and other potential pollution sources. Groundwater flow directions will be directed towards the mining area due to the mine dewatering. Therefore, no

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contamination will be able to migrate away from the mining area. The water balancing dam and pollution control dams will be lined, thereby preventing any contamination of the underlying aquifers.

The development of the contaminant plume away from the discard area was simulated using the 3-D numerical contaminant transport model. As discussed in Section of ABA and static leach testing results indicate that the roof and floor material is unlikely to lead to the formation of acid conditions. However, in order to be conservative, it has to be assumed that some coal seam material will be included in the discard dump that can potentially be a source of contamination.

Leach testing shows that no elements will be present in significant concentrations that can lead to health impacts. Therefore, it was decided to apply a generic approach. The results can then be applied to any contaminants that may be identified from further acid base accounting and leach testing. A **value of 100** is assigned to the pollution source areas, in this case the discard area. In effect this represents 100 % of the starting concentration of any contamination. The plume distribution then represents the percentage of starting concentration that will be measured at a specific point. For example should the plume at a specific point indicate a value of 50, it indicates that the element concentration at the point and time is expected to be 50 % of the initial source concentration.

As long as new material is dumped on the discard dump it can be assumed that the maximum starting concentration will easily be maintained. Therefore, a source value of 100 at the discard dump is used for the life of mine. Hodgson and Krantz (1995) found that recharge in discard dumps are artificially increased compared to natural recharge values. They came to the conclusion that recharge from discard areas into the underlying aquifers can be as high as 15 to 20 % of mean annual rainfall (MAR). For the purpose of this study an average recharge value of 15 % of MAR was applied.

The resulting plume is shown in *Figure 8- 7*. It can be seen that at the end of life of mine (year 20) the plume will have migrated into the pit area. Once the contamination enters the higher transmissivity rehabilitated pit area migration direction will change towards the active open area from where dewatering takes place. No contamination away from the pit area is expected. Modelling results show that very little contamination is expected to enter the deeper aquifer and the impact on element concentrations in the lower aquifer will be less than 2 % of the source concentrations.

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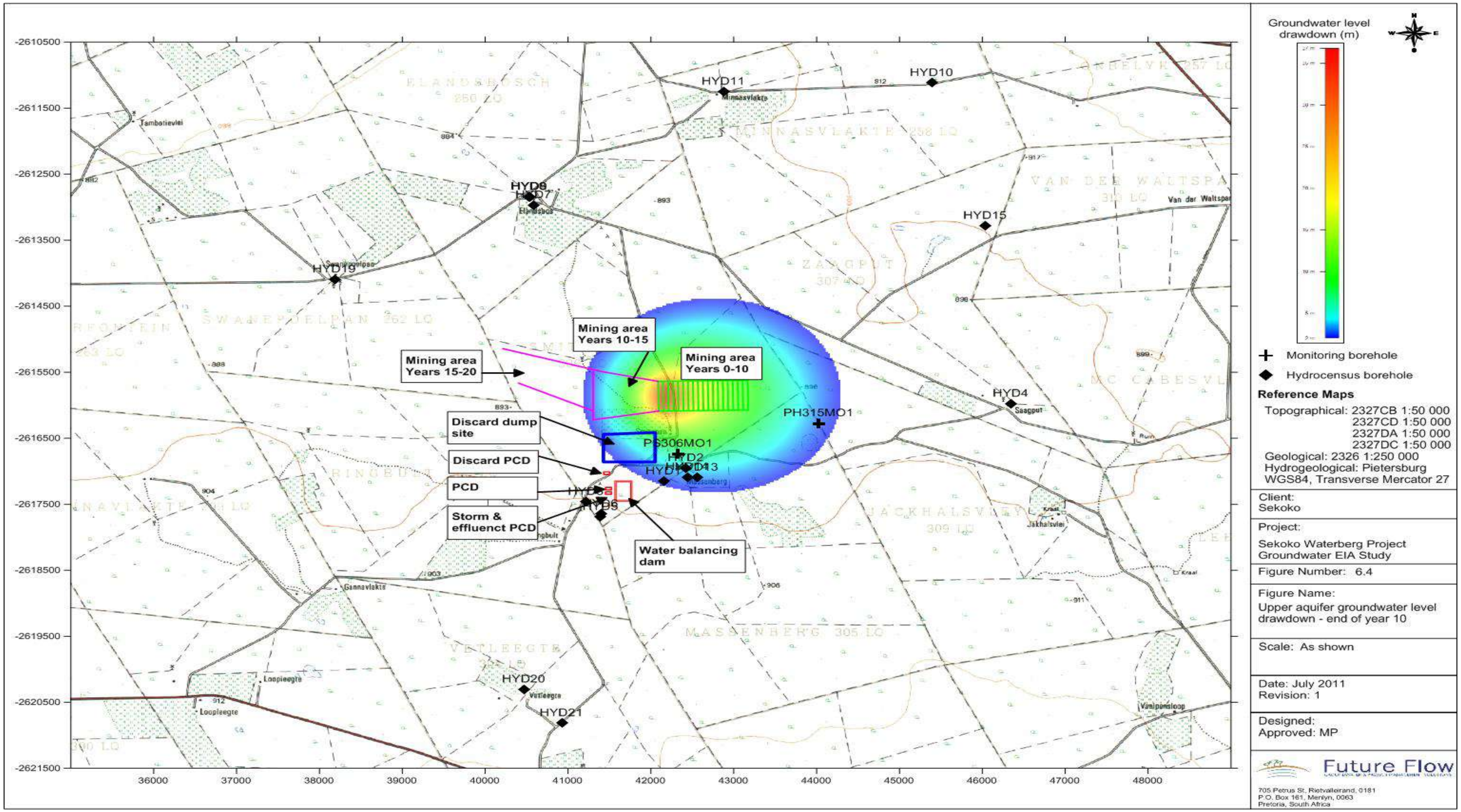

Figure 8-3: Upper aquifer groundwater leel drawdown – end of year 10(Hydrogeological study, 2011 by Future Flow GPMS cc)

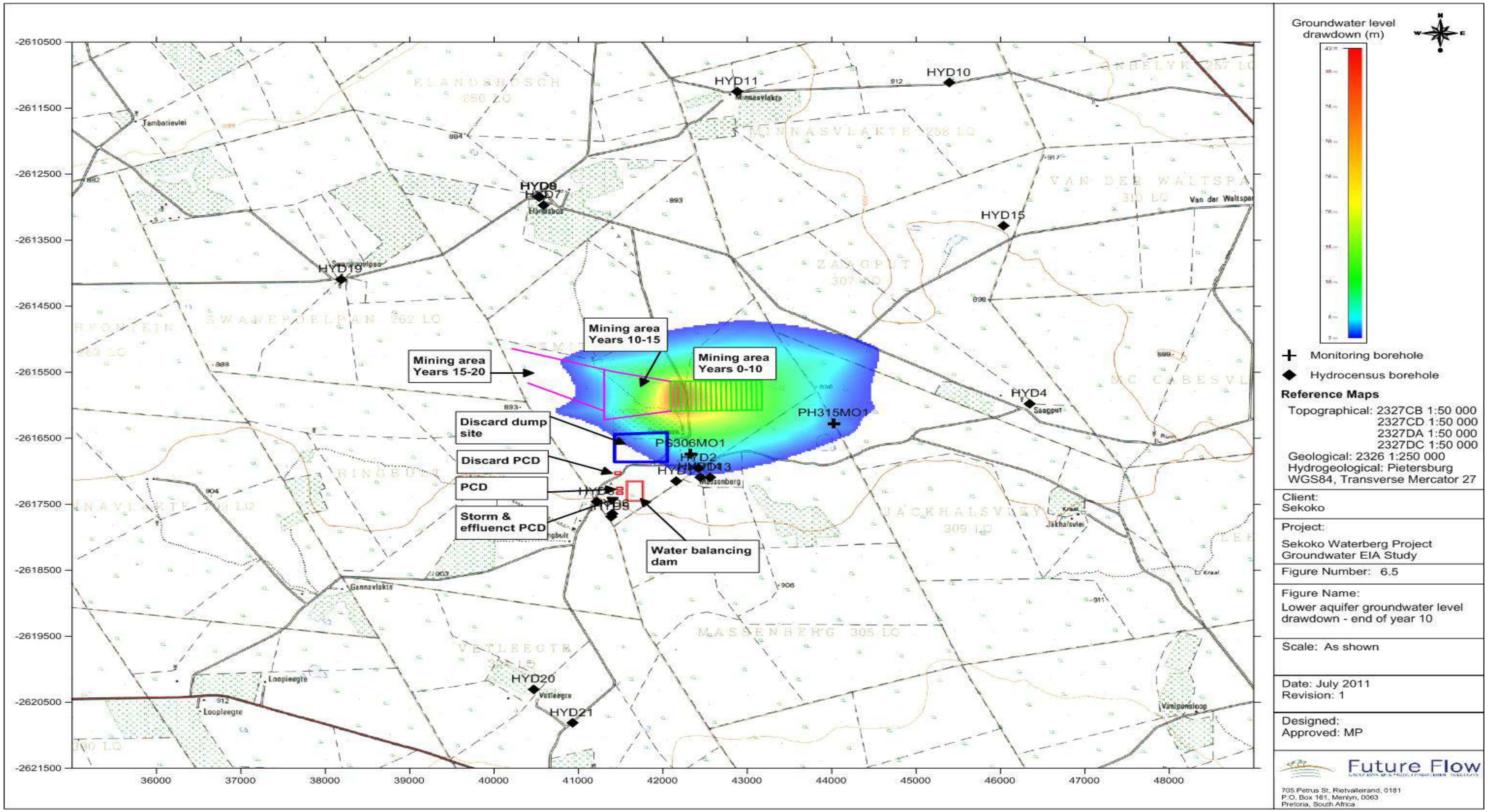

Figure 8- 4: Lower aquifer groundwater level drawdown – end of year 10(Hydrogeological study, 2011 by Future Flow GPMS cc)

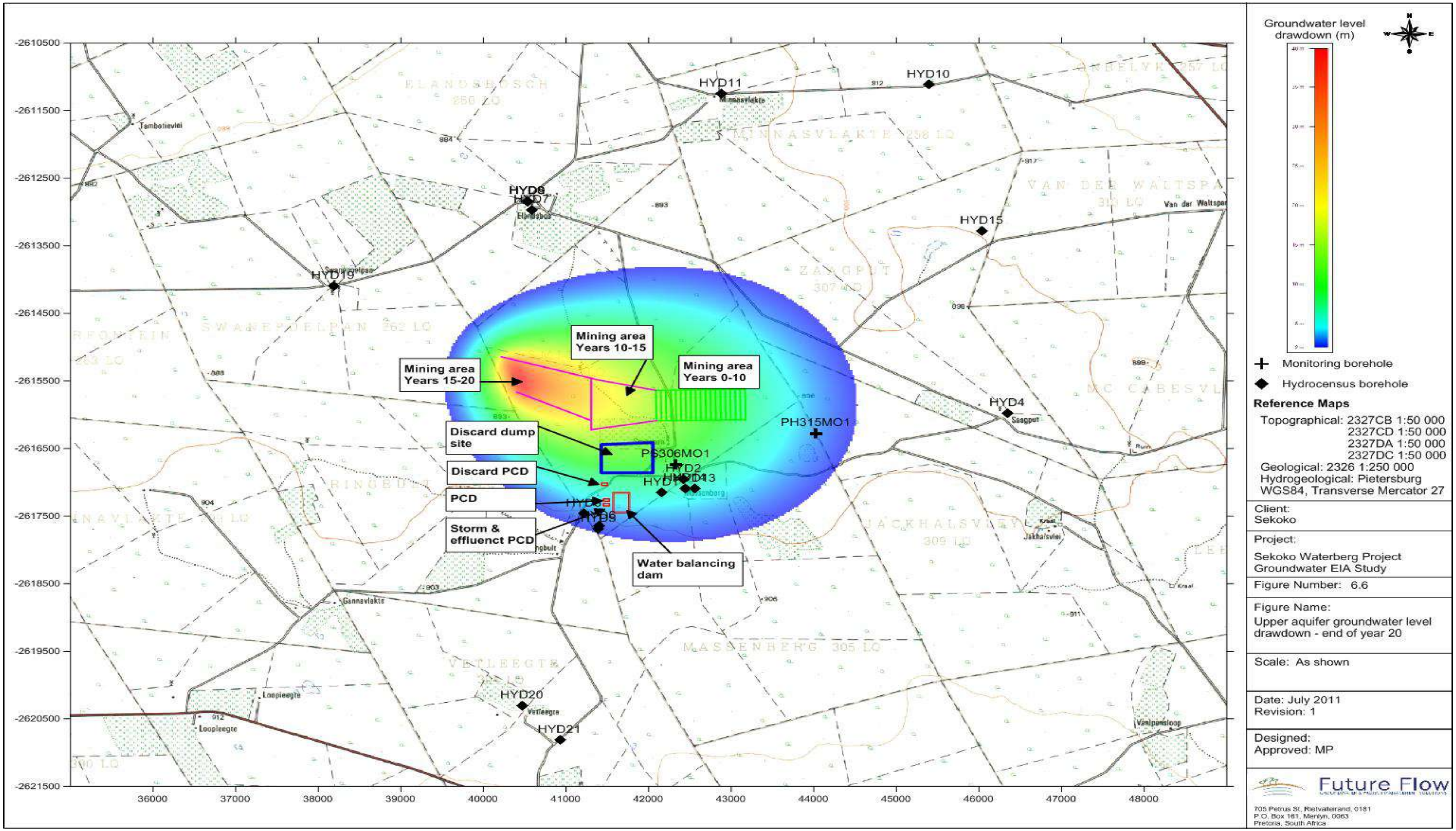

Figure 8-5: Upper aquifer groundwater level drawdown – end of year 20(Hydrogeological study, 2011 by Future Flow GPMS cc)

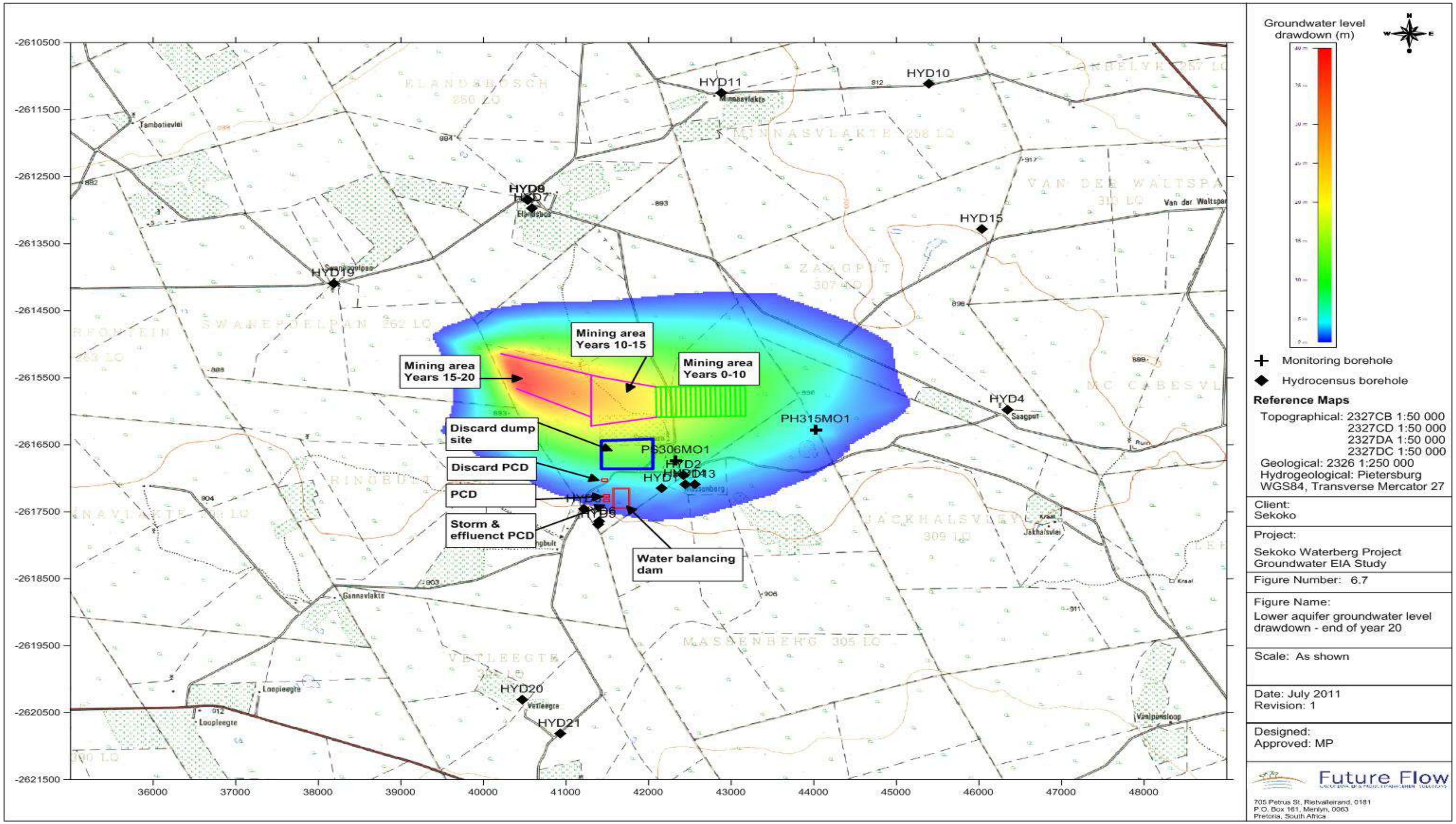

Figure 8- 6: Lower aquifer groundwater level drawdown – en of year 20(Hydrogeological study, 2011 by Future Flow GPMS cc)

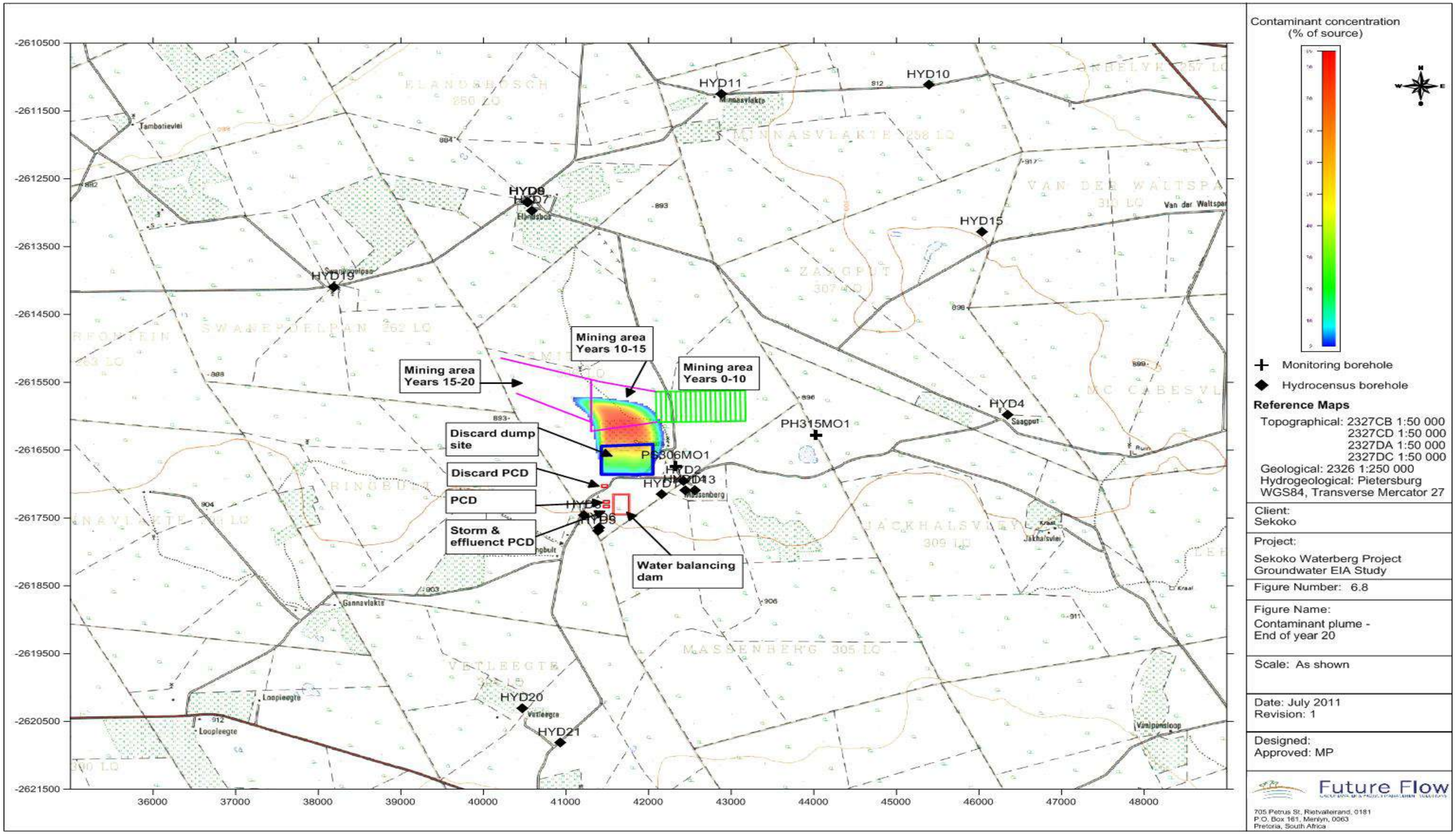

Figure 8- 7: Contaminant plume – end of year 20(Hydrogeological study, 2011 by Future Flow GPMS cc)

8.3 Decommissioning phase

Decommissioning of the mined out area will effectively start once rehabilitation of an area starts. Groundwater levels in rehabilitated areas will start to recover before the official end of life of mine. General decommissioning will start at the end of year 20 when mining is completed. Material that is potentially contaminating will be removed from the water balancing dams and PCDs. The coal stockpiles will be rehabilitated.

It is planned that material stored on the discard dump will be backfilled into the pit as part of the rehabilitation plan from year 5 of the life of mine onwards. Following the "Backfill Option 1" as detailed in the environmental management plan the discard material will be encapsulated in clay layers, thereby preventing water ingress and limiting the potential for contamination from the backfilled discard material.

Vegetation will then be planted and established. This will reduce ponding of rainwater on the discard dumps and promote runoff thereby reducing the recharge from rainfall. For the purpose of this study it was assumed that the recharge into the discard material will be reduced to around 1 % of MAR under this scenario. The decommissioning phase is expected to be relatively short and no significant impacts are expected during this short time period.

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8.4 Long term post-mining phase

8.4.1 Recovery of groundwater levels

In the post mining period groundwater levels in the study area will continue to recover to near pre-mining levels. Numerical modelling results show that the groundwater level in the upper and lower aquifers will rise relatively quickly during the initial years, and then stabilise from around 40 years after closure onwards.

8.4.2 Contamination of the surrounding aquifers

Long term (up to 100 years after mine closure) contaminant migration pathways are simulated using the numerical groundwater flow and contaminant transport models to determine the contaminant migration patterns. As described in Section of the ABA test results show that the formation of acid mine drainage from roof and floor material is not likely. However, the exposed coal seams in the mined-out area will be subjected to oxidation and therefore it can be expected that some acid mine drainage will form during the early years after mine closure. Once the coal seams are submerged below the recovering groundwater level oxidation and chemical reactions will largely stop.

It is planned that material stored on the discard dump will be backfilled into the pit as part of the rehabilitation plan from year 5 of the life of mine onwards. Following the "Backfill Option 1" as detailed in the environmental management plan the discard material will be encapsulated in clay layers, thereby preventing water ingress and limiting the potential for contamination from the backfilled discard material.

Because no data is available on the rate at which elements will be leached from the discard material (assuming that application for exemption to backfill the discard material into the pit will not be granted and the surface discard will be maintained) and rehabilitated opencast mine some assumptions had to be made regarding the source concentrations at the rehabilitated mine area and the discard dump over time:

- Years 0 to 10 after closure: A source concentration of 100 % of original concentration is assumed;
- Years 10 to 20 after closure: A source concentration of 50 % of original concentration is assumed;

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- Years 20 to 50 after closure: A source concentration of 25 % of original concentration is assumed; and
- Years 50 to 100 after closure: A source concentration of 10 % of original concentration is assumed.

Modelling simulations show that contaminant migration in the upper aquifer will be in a down-gradient direction towards the north and northwest away from the mined-out area.

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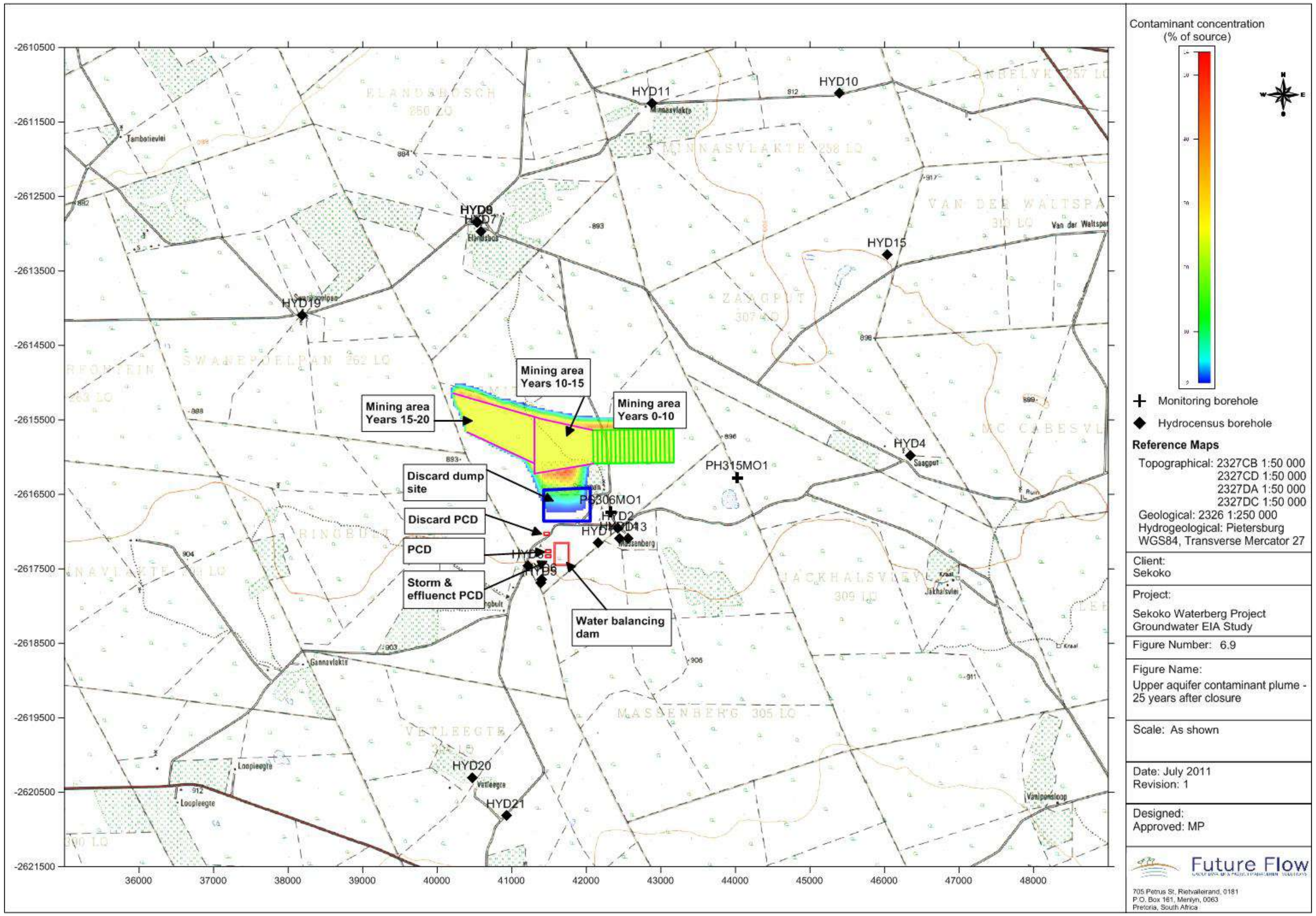

Figure 0.1: Upper aquifer contaminant plume –25 years after closure(Hydrogeological study, 2011 by Future Flow GPMS cc)

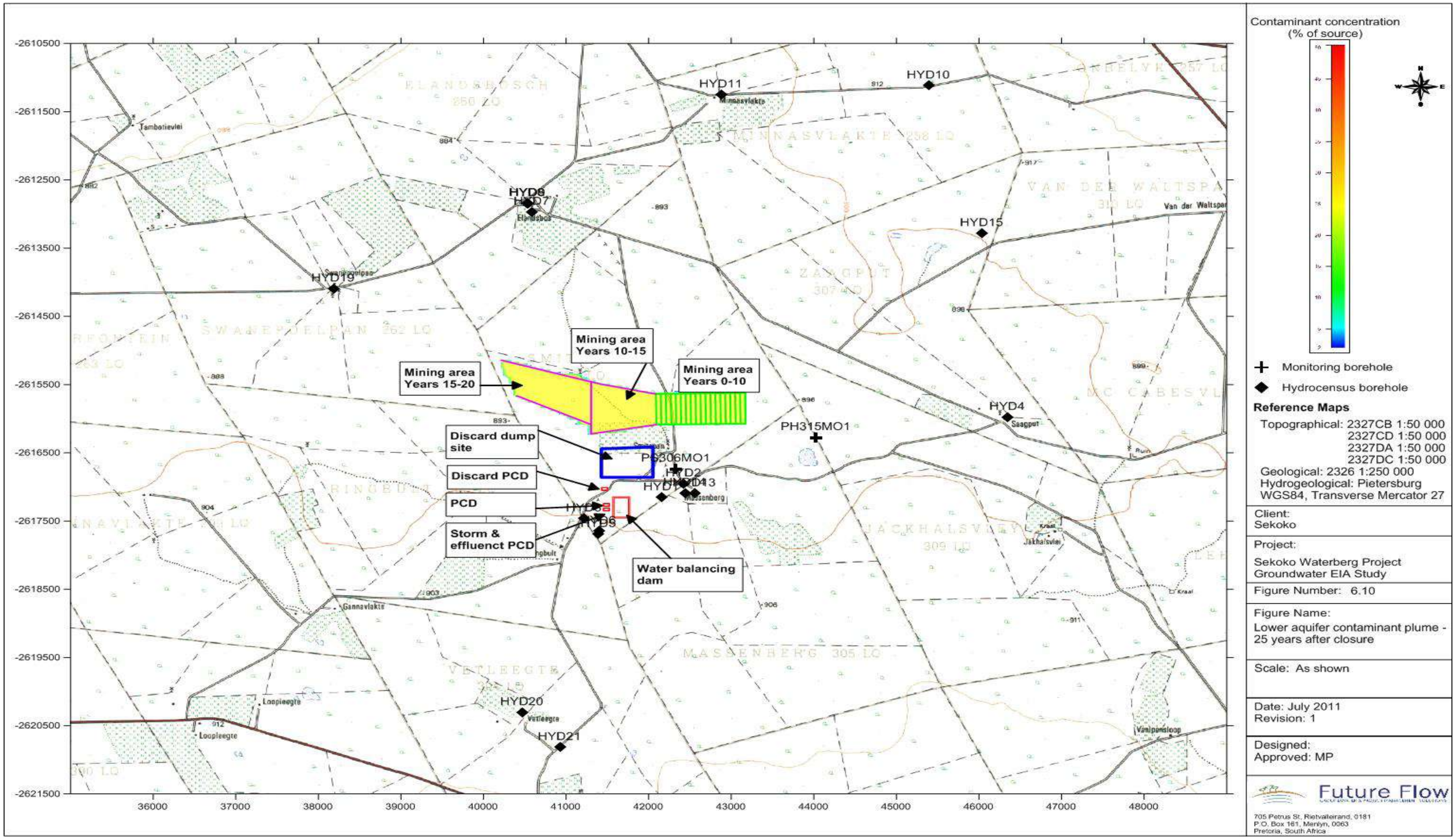

Figure 8- 8: Lower aquifer contaminant plume –25 years after closure(Hydrogeological study, 2011 by Future Flow GPMS cc)

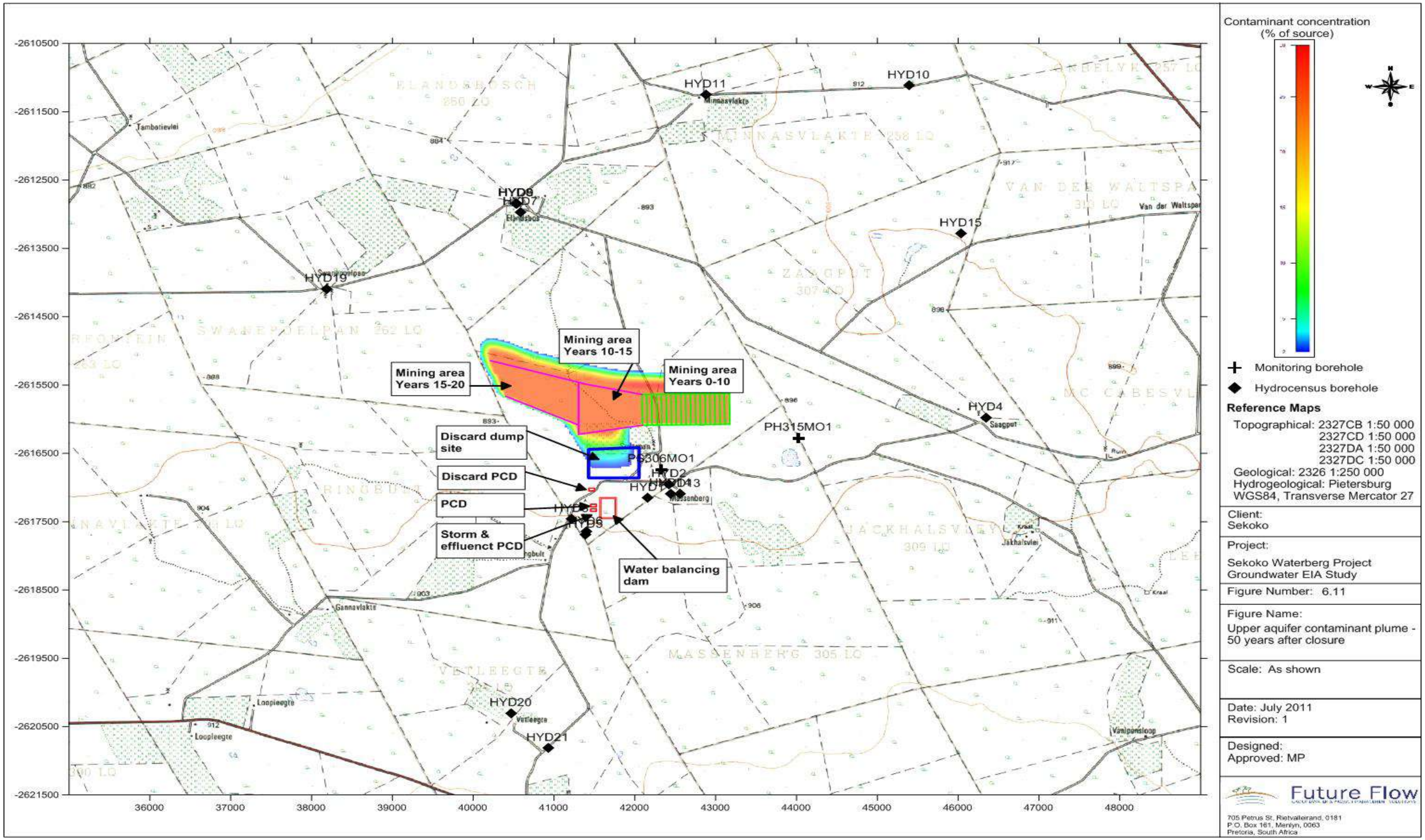

Figure 8-9: Upper aquifer contaminant plume – 50 years after closure(Hydrogeological study, 2011 by Future Flow GPMS cc)

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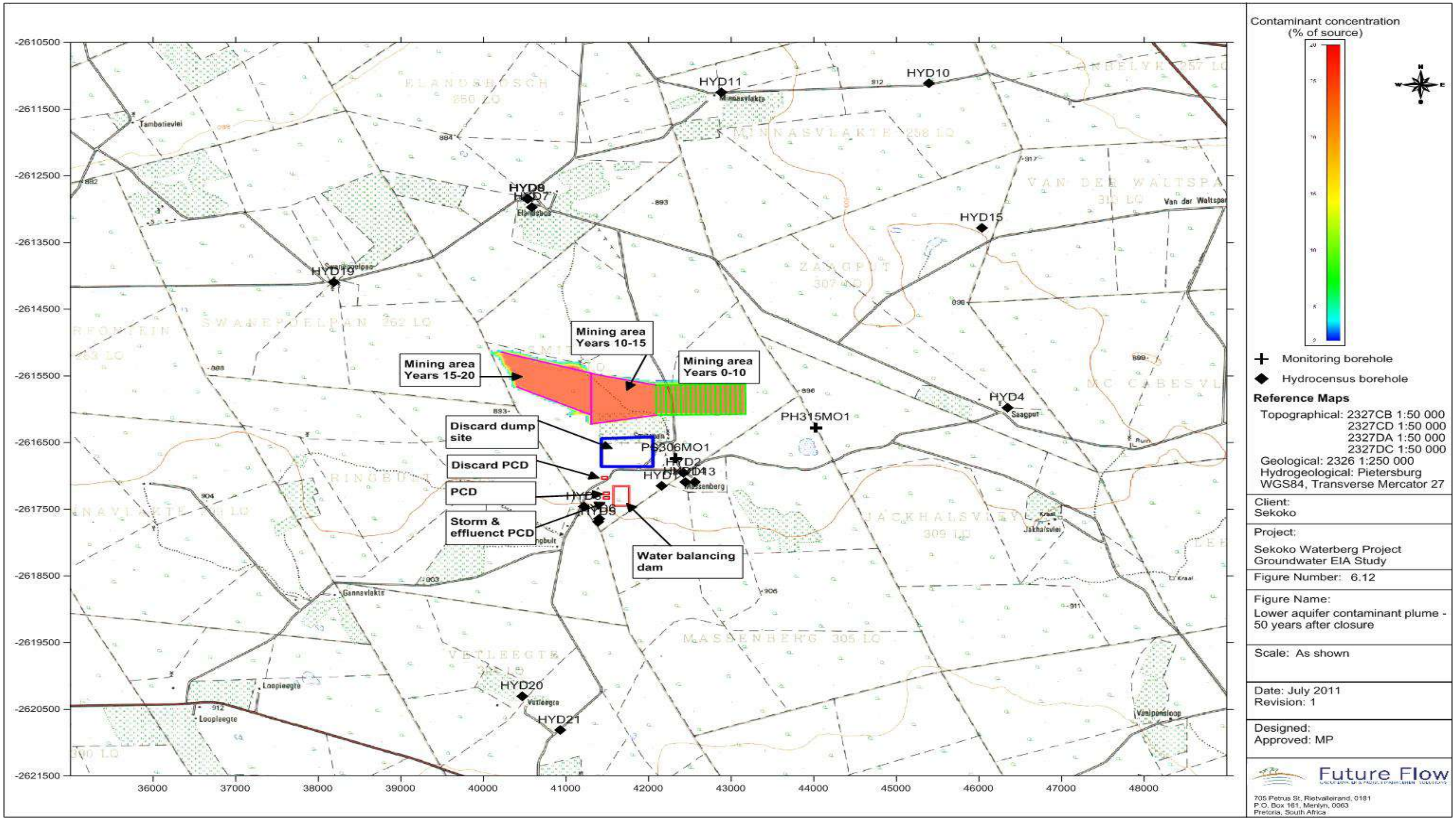

Figure 8- 10: Lower aquifer contaminant plume – 50 years after closure(Hydrogeological study, 2011 by Future Flow GPMS cc)

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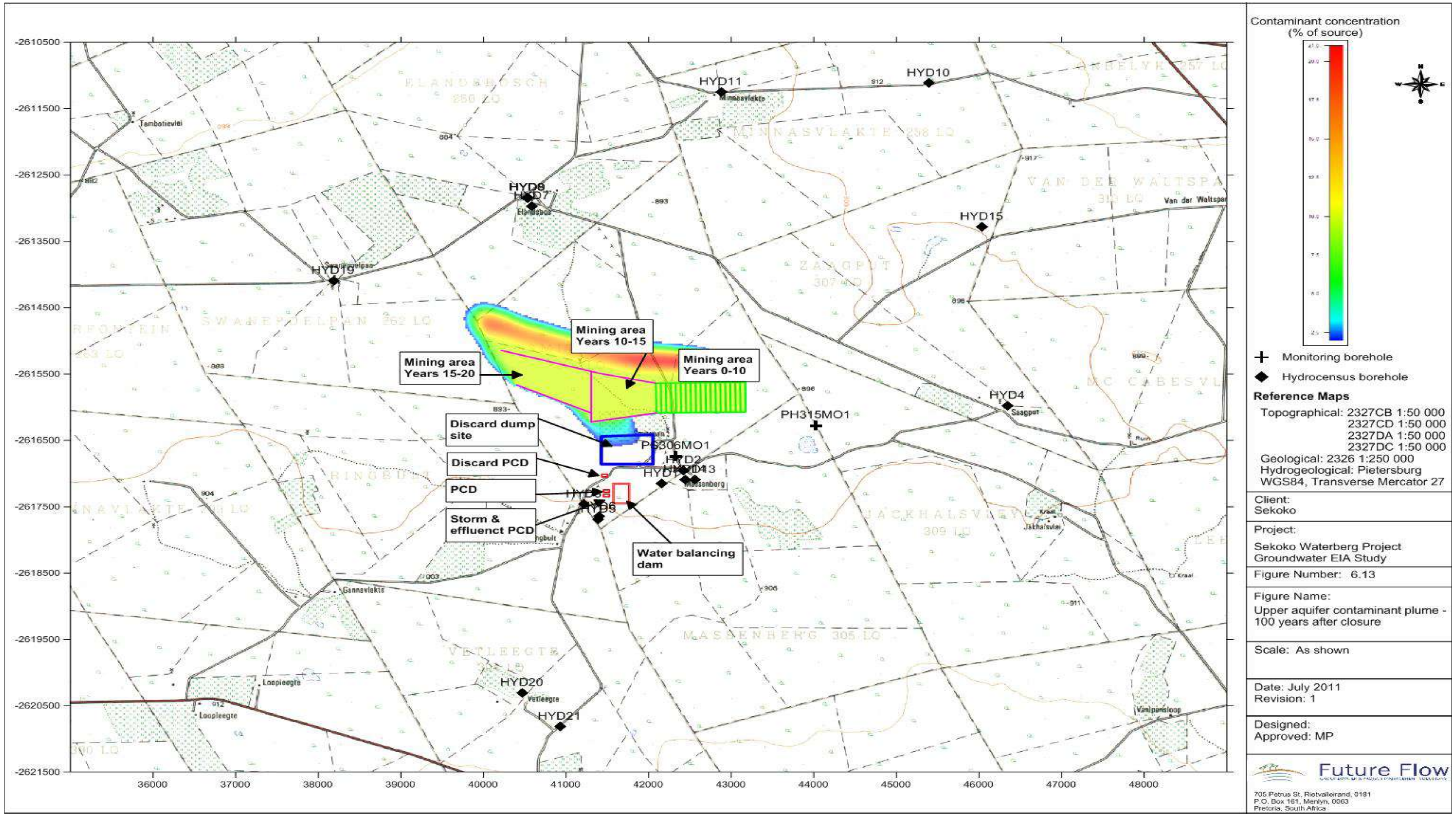

Figure 8-11: Upper aquifer contaminant plume – 100 years after closure(Hydrogeological study, 2011 by Future Flow GPMS cc)

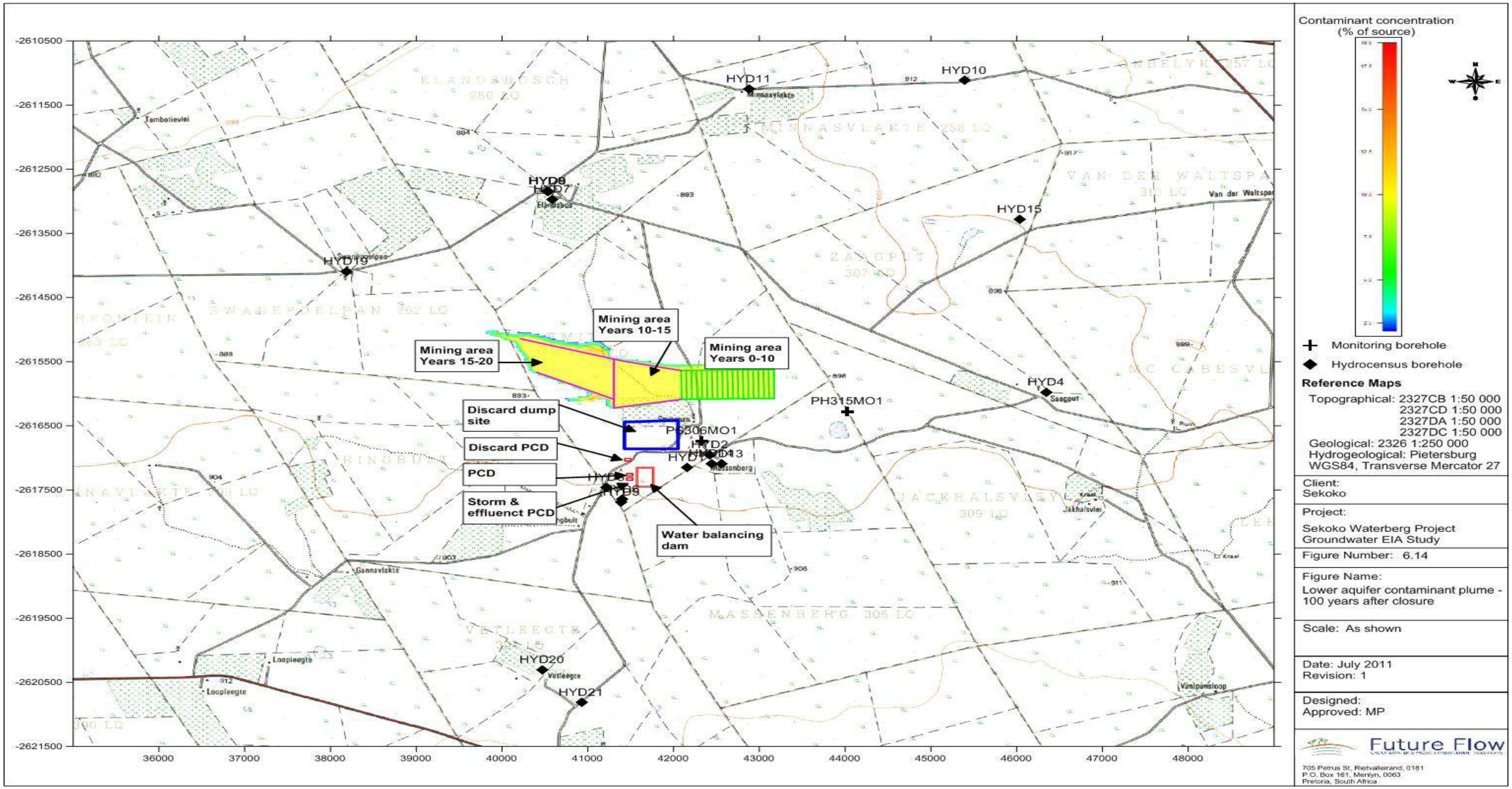

Figure 8-12: Lower aquifer contaminant plume – 100 years after closure (Hydrogeological study, 2011 by Future Flow GPMS cc)

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9 Groundwater monitoring plan

Groundwater management strategies for most mining and industrial activities are limited and emphasis falls on prevention of pollution rather than the treatment thereof. Early detection of contamination is the key to react and manage any possible sources of pollution effectively. This will assist in identifying potential future impacts from mining operations on the groundwater environments.

9.1 Groundwater monitoring system

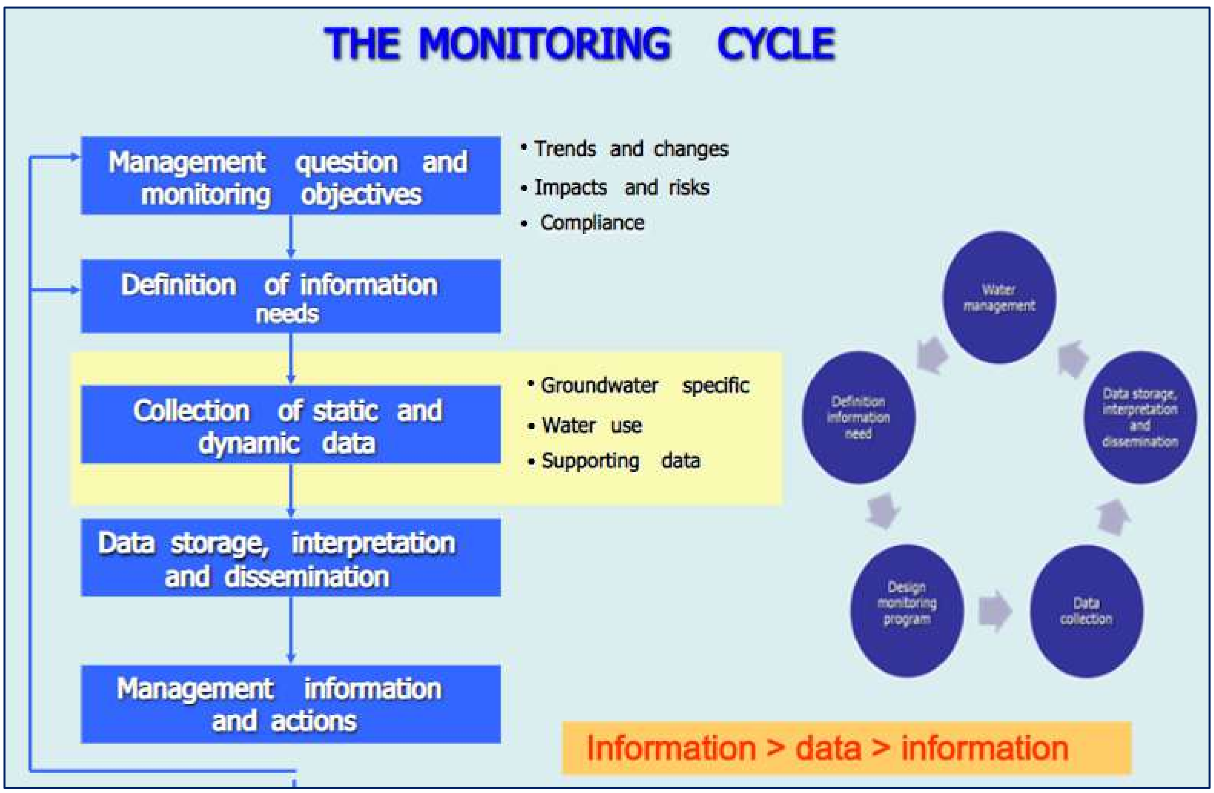

Figure 9-1: Groundwater monitoring cycle (IWSD, 2011)

9.1.1 System response monitoring network

9.1.1.1 Groundwater contamination

Groundwater levels must be recorded on quarterly basis using an electrical contact tape or pressure transducer, to detect any changes or trends in groundwater flow direction.

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Contamination from the coal stockpile and other surface infrastructure (pollution control dams, water balancing dams etc) can contaminate the underlying aquifers. It is expected that surface infrastructure such as pollution control dams and water balancing dam will be fully lined to prevent any contamination seeping into the underlying aquifers as per normal practise. These ponds should also be sized and designed to be able to accommodate 1:50 year rainfall events without accidental spillage occurring.

Dedicated monitoring boreholes should be installed to monitor for groundwater level and quality changes close to the pollution control dams, discard dump, and plant area. Additional monitoring boreholes around the opencast pit area should also be considered as the mine layout plan was not available when the initial three boreholes were drilled.

9.1.1.2 Sampling Method and Preservation

- One litre plastic bottles, with a plastic cap and no liner within the cap are required for most sampling exercises. Glass bottles are required if organic constituents are to be tested for. Sample bottles should be marked clearly with the borehole name, date of sampling, water level depth and the sampler's name.
- Water levels (mbgl) should be measured prior to taking the sample, using a dip meter Each borehole to be sampled should be purged (to ensure sampling of the aquifer and not stagnant water in the casing) using a submersible pump or in the event of a small diameter borehole, a clean disposable polyethylene bailer. At least three borehole volumes of water should be removed through purging; or through continuous water quality monitoring, until the electrical conductivity value stabilizes Metal samples must be filtered in the field to remove clay suspensions
- Samples should be kept cool in a cooler box in the field and kept cool prior to being submitted to the laboratory; and
- The pH and EC meter used for field measurements should be calibrated daily using standard solutions obtained from the instrument supplier.

9.1.2 Sampling Locations

The main objectives in positioning the monitoring boreholes are to:

- Monitoring of groundwater migrating away from the pit area and
- Monitoring the lowering of the water table and the radius of influence

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9.1.3 Data Management

In any project, good hydrogeological decisions require good information developed from raw data. The production of good, relevant, and timely information is the key to achieve qualified long-term and short-term plans. For the minimisation of groundwater contamination it is necessary to utilize all relevant groundwater data.

An excel-based database during the course of this investigation and it is recommended that Lephalale Coal Concessions (Pty) Ltd utilizes this database and continuously update and manage it as new data becomes available. Monitoring results will be captured in an electronic database as soon as results become available allowing:

- Data presentation in tabular format
- Time-series graphs with comparison abilities
- Graphical presentation of statistics
- Presentation of data, statistics and performance on diagrams and maps and
- Comparison and compliance to legal and best practice water quality standards.

9.1.4 Reporting

Based on the recorded water quality data, the data management functions as described will be carried out and reported to mine management on a monthly basis. The contents of the report should include the monthly water monitoring results and trends at surface points, as well as comments on the effectiveness of the mitigation measures and monitoring program.

Reporting to the authorities, should be as specified in the permitting/licensing conditions. Any accidental release of pollutants or possible polluting substances should be reported to the relevant authorities as specified in the permitting conditions.

9.1.5 Monitoring frequency

Groundwater is a slow-moving medium and drastic changes in the groundwater composition are not normally encountered within days. Groundwater monitoring should be conducted quarterly. Samples should be collected by an independent groundwater consultant, using best practice guidelines and should be analysed by a SANAS accredited laboratory. Groundwater levels must

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be recorded on a quarterly basis to within an accuracy of 0.1m using an electrical contact tape, float mechanism or pressure transducer, to detect any changes or trends in groundwater levels.

9.2 Monitoring parameters

Table 9-1: Groundwater monitoring

Class	Parameter	Frequency	Motivation
Physical	Static groundwater levels	Monthly	Time dependent data is required for transient calibration of numerical flow models. Changes in static water levels may give early warning of dewatering in the area.
	Rainfall	Daily	Recharge to the saturated zone is an important parameter in assessing groundwater vulnerability. Time dependent data is required for transient calibration of numerical flow models.
	Groundwater abstraction rates if present	Monthly	Response of groundwater levels to abstraction rates can be used to calculate aquifer storativity – important for groundwater management.
Chemical	Major chemical parameters: Ca, Mg, Na, K, NO3, SO4, Cl, Fe, Alkalinity, pH, EC TPH (Total Petroleum Hydrocarbons)	Quarterly	Background information is crucial to assess impacts during operation and thereafter. Changes in chemical composition may indicate areas of groundwater contamination and be used as an early warning system to implement management/remedial actions. Legal requirement. Groundwater chemistry forms an integral part of the development of conceptual models.
	Minor chemical constituents Full scan of trace metals	Quarterly	Changes in chemical composition may indicate areas of groundwater contamination and be used as an early warning system to implement management/remedial actions. Legal requirement

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Other Stable isotopes	Ad hoc basis	The monitoring program should allow for research and refinement of the conceptual geohydrological model. This may, from time to time, require special analyses like stable isotopes

9.3 Monitoring boreholes

Monitoring boreholes should be located around the mining Pit, on upper levels and near the river to monitor the flow direction, Rate of water flow as well as water quality. The boreholes should be constructed such that they can be used to reliably monitoring groundwater level and quality changes in the area. Table 9-2 below is the list of the chosen monitoring boreholes based on the hydrocensus data that was collected within the mining right farms.

Table 9-2: Monitoring boreholes locations

Borehole ID	Latitude	Longitude	Comments
HK 01	-23,701022	27,434892	Not well constructed, improvement is needed, a collar height and name of the borehole must be clearly stated at the borehole.
HK 02	-23,700059	27,4377	Not well constructed, improvement is needed, a collar height and name of the borehole must be clearly stated at the borehole.
HK 03	-23,701022	27,434892	Not well constructed, improvement is needed, a collar height and name of the borehole must be clearly stated at the borehole.
HK 04	-23,696716	27,43354	Not well constructed, improvement is needed, a collar height and name of the borehole must be clearly stated at the borehole.
HK 05	-23,696654	27,4335226	Not well constructed, improvement is needed, a collar height and name of the borehole must be clearly stated at the borehole.
Monitoring BH 1	-23,700341	27,437665	Locked with Key, properly constructed borehole, improvement needed
SLCC-BH10	-23,656225	27,412029	Well constructed borehole, brackish colour water sample was collected, closed and cased.
R303712 (Monito	-23,673469	27,408699	Not in use, cased and not closed, improvement is needed
SLCC-BH13	-23,63374	27,424219	Properly constructed borehole, closed with steel casing, light black color water sample
SLCC-BH14	-23,619397	27,406151	Steel stick out with plastic inner casing, clear color water sample
SLCC-BH15	-23,639702	27,393785	Steel stick out with plastic inner casing, clear color water sample
SLCC-BH17	-23,656111	27,402883	Properly constructed borehole, closed with steel casing, clear color water sample
SLCC-BH18 (053)	-23,656155	27,402878	Properly constructed borehole, closed with steel casing, dark brown color water sample
SLCC-BH20	-23,65368	27,416657	Pumps about 1500l/h to the resrvoir located at the farmhouse
SLCC-BH21	-23,680182	27,429703	Pumps about 1000l/h to the tank
SLCC-BH22	-23,647153	27,431541	Dry borehole

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10 Groundwater Environmental Management Programme

10.1 Current groundwater conditions

Groundwater occurs within the joints, bedding planes, and along fractures within the Waterberg Group sediments. Groundwater potential is generally low in these rocks, with 87% of borehole with yields less than 3 l/s.

10.2 Predicted impacts of facility mining

Impact assessment and mitigation measures table

Severity of impact	RATING	Spatial scope of impact	RATING	Duration of Impact	RATING	Frequency of Activity	RATING	Frequency of Impact	RATING
Insignificant/ non-harmful	1	Activity specific	1	1 day to 1 month	1	Annually or less/ low 6	1	Almost never	1
Small / potential harmful	2	Mine specific(within the mine boundary)	2	1 month to 1 year	2	Monthly/temporary	2	Highly unlikely	2
Significant/ Slightly harmful	3	Local area (within 5km of the mine boundary)	3	1 year to 10 years	3	Monthly/ Infrequent	3	Unlikely	3
harmful	4	Regional	4	Operational life	4	Weekly/life of operation/regularly/likely	4	Likely	4
extremely harmful	5	National	5	Post-closure/ Permanent	5	Daily/ permanent/high	5	Highly likely/	5

The Environmental Significance is derived from the below mentioned variables:

Severity (Magnitude) Of Impact **(M)**

Spatial Scope **(S)**

Duration of Impact **(D)**

Frequency of Activity **(Fa)**

Frequency of Impact **(Fi)**

Environmental Significance = (Severity of Impact +Spatial Scope + Duration of Scope) X (Frequency of Activity +Frequency Of impact)

SP= (M+S+D) x (FA+ FI)

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Significance Rating Matrix

(Severity(M) + Spatial scope(S) + Duration(D))

(Frequency Of Activity (Fa) + Frequency Of Impact(Fi))

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	4	6	8	10	12	14	16	18	20	22	24	26	28	30
3	6	9	12	15	18	21	24	27	30	33	36	39	42	45
4	8	12	16	20	24	28	32	36	40	44	48	52	56	60
5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
6	12	18	24	30	36	42	48	54	60	66	72	78	84	90
7	14	21	28	35	42	49	56	63	70	77	84	91	98	105
8	16	24	32	40	48	56	64	72	80	88	96	104	112	120
9	18	27	36	45	54	63	72	81	90	99	108	117	126	135
10	20	30	40	50	60	70	80	90	100	110	120	130	140	150

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Table 10-1: Impact assessment and mitigation measures table

	Potential environmental impact	Environmental significance before mitigation							Recommended measures/remarks for mitigation	Environmental significance after mitigation						
		M	S	D	Fa	Fi	total	SP		M	S	D	Fa	Fi	total	SP
OPERATIONAL PHASE IMPACTS	Increased groundwater contamination potential due to overburdened stockpiles.	1	2	3	2	2	24		**1.** The overburden stockpiles ' compact footprint region to minimize groundwater infiltration. **2.** Stormwater run-off from the overburden stockpiles will be transferred to the dam for dirty water / pollution control. **3.** A surveillance program for groundwater resources will be introduced to identify contamination of groundwater.	1	2	2	1	2	22	
	Fuel & hydrocarbon spills from cars can lead to contamination of groundwater	1	4	2	2	3	35		Clean up immediately after accidental spills & Divert run-off from highways that may contain hydrocarbons into pollution control dams to regulate the pollution.	2	1	3	2	1	18	

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Borehole / aquifer re duction outcomes fr om pit dewatering	2	1	3	4	4	48	An area of impact will be caused by pit dewatering. In the case of the proposed mining area, the zone of influence will not extend beyond the estimated 300 m, thus the yields of any supply boreholes or springs around the mining area are not anticipated to affect. Temporary water supply by the mine is a possible mitigation against such an effect.	2	1	3	1	1	12
Open cast mining will result in pit inflows below the water table.	2	3	5	3	4	70	It is not possible to mitigate pit inflows (needed for a safe working environm ent). Provision must be produced for t he treatment of pit inflows within the mine water balance. It will also need t o be treated before discharge.	2	3	5	3	4	70
Water in dirty water dams can affect the quality of the ground water	2	2	3	5	3	55	Dams to regulate pollution must be lin ed and intended to meet the require ments of NEMA and NWA (Act 36 of 1 998). Manage any leaks and spills to a void contamination of groundwater. Monitor groundwater to detect conta mination of groundwater.	2	1	2	2	1	15
Reduction of the bas eflow due to mining	2	3	5	4	4	80	Mine dewatering will have a negative impact on the baseflow contribution of the saalboomspruit river tributary. It will not be possible for the rehabilitate d open void to provide a comparabl	2	3	5	4	4	80

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								e baseflow contribution as before min ing (hundred fold less).						
POST CLOSURE IMPACTS	Contribution of salt lo ad towards the close st river	3	4	4	5	3	88	***1.*** In the backfilled open pit section, groundwater concentrations will be restored after closure, flowing away from the mine to the river's lesser lying tributary. A prospective pollution plume within the stream may result in enhanced salt load. 2. Under the topsoil cover, an impermeable layer can be introduced that will need to be compacted to avoid water from entering. Monitoring of prospective rivers by surface water will be crucial. Quarterly groundwater sampling must be performed to create a plume motion trends database to assist in the eventual closure of the mine.	3	2	3	5	5	80
	Rebound water con centrations can caus e decant within bac kfill material.	2	4	4	4	5	90	Under the topsoil cover, an impermeable layer can be implemented which will need to be compacted to avoid water from entering, resulting in rebounding and decanting water concentrations. To monitor the water level and water	3	3	4	5	4	90

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									quality, boreholes should be mounted nearer to the decant points.						
	Aquifer contamination due to backfill	**3**	**5**	**4**	**5**	**5**	**110**		Migration of the pollution plume to the north-east of the backfill region may influence the use of gradient groundwater. The final topography of the backfilled opencast should be designed to divert runoff from the opencast region.	**4**	**2**	**3**	**4**	**5**	**81**

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10.3 Lowering of groundwater levels during mining

During mining it will be of importance to do dewatering and depressurization. **Dewatering** is all about draining soil/ rockmass. This leads to lowering of the water table. This will help in reducing wet pit problems and reduce stability problems. **Depressurisation** is all about reducing pore pressure. Leading to lowering of the potentiometric surface.

Depressurisation Approaches:

- Active (or advanced):
  - depress/dewatering ahead of mining
  - pumping from boreholes
  - active pumping from deep sumps in pit base
  - drainage adits/galleries ahead of mining
- Passive(or reactive):
  - natural pore pressure dissipation through seepage
  - shallow in-pit sumps or catch drains on berms
- Hybrid (bit of both):
  - drainage adits/galleries after mining commences
  - drain holes in pit walls and UG floors/backs

The Lephalale Coal Concessions mine is located in an area where underground water mainly occurs in fractures, the possibilities are that when they mine they will intersect these fractures, and underground water will seep through. These water will be pumped and stored in a PCD (if dirty) and in tanks if in good conditions.

This activity of pumping out water lowers the water table. A cone of depression will be formed around the boreholes which will be drilled for the operation of the mine. Monitoring boreholes should be drilled in the upper slope, lower slope and near the river to monitor the groundwater level decline or rise.

10.4 Rise of groundwater levels post- mining

Effects of Decanting in the Waterberg

Decanting is a surface discharge of water from an abandoned mine. Decanting in open cast mines is also highly influenced by the recharge in an area. According to **Error! Reference source n**

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ot found. below, the recharge in this area is about 1.5% tested using the chlorine and earth methods. In Waterberg the pits will highly unlikely decant because of:

- Low rainfall
- Low recharge
- High evapotranspiration and
- Natural water level of 30m

11 Post closure Management Plan

The rehabilitation and closure actions for the particular infrastructure are detailed below. Although concurrent rehabilitation occurs during the operational phase, it has been included in this section as it directly impacts on final rehabilitation and closure.

11.1 Remediation of physical activity

Crushing and Screening Plant

The crushing and screening plant will need to be free from contamination and then decommissioned. Infrastructure that can be reused or sold should be removed to defray costs and remaining structures should be demolished to 1 m below surface and the demolition rubble removed. If contamination is discovered, this soil should be removed and disposed of in the appropriate waste disposal facility.

Rehabilitated areas must be shaped to be free draining and roughly emulate the surrounding surface topography. Re-instate natural drainage lines and encourage water flow off the facility. Replace topsoil to 300 mm and rip soil to 200 mm to reduce compaction, thereafter, establish successful vegetation cover. Remove alien invasive vegetation. Monitor required aspects according to guidelines stipulated in specialist reports appended to the EIA.

Office Complex (change house, workshop, offices)

Infrastructure such as the offices, administration buildings and workshops should be removed, unless the liability is taken over by another party. If complete infrastructure removal is chosen, Infrastructure that can be re-used or sold should be removed to defray costs and remaining structures should be demolished to 1 m below surface and the demolition rubble removed.

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If contamination is discovered, this soil should be removed and disposed of in the appropriate waste disposal facility. Rehabilitated areas must be shaped to be free draining and roughly emulate the surrounding surface topography. Replace topsoil to 300 mm and rip soil to 200 mm to reduce compaction, thereafter, establish successful vegetation cover. Remove alien invasive vegetation. Monitor required aspects according to guidelines stipulated in specialist reports appended to the EIA

11.2 Remediation of storage facilities

Pollution Control Dam and water pipelines

Pollution control dams must be desilted if necessary. Thereafter the liners can be removed and disposed of at the correct hazardous waste disposal facility. The dam walls must be dozed and dam infrastructure demolished and also disposed of at the correct hazardous waste disposal facility. Additionally, supporting plinths for pipeline as well as foundations and other associated infrastructure must be demolished to 1 m below surface and the demolition rubble removed.

If contamination in the soil is discovered, this soil should be removed and disposed of in the appropriate waste disposal facility. Rehabilitated areas must be shaped to be free draining and roughly emulate the surrounding surface topography Replace usable topsoil (all usable topsoil stripped from these areas should be placed back in these areas) and rip soil to 200 mm to reduce compaction, thereafter establish successful vegetation cover. Remove alien invasive vegetation. Monitor required aspects according to guidelines stipulated in specialist reports appended to the EIA.

Aboveground Diesel Storage Tanks

Remove tank and associated infrastructure from site (it is assumed that all contamination is removed during operation). Thereafter, demolish concrete bund wall and dispose of contaminated material at a hazardous waste facility. Once the site has been cleared of all infrastructure and rubble and no contamination is present, the exposed underlying materials should be reshaped to create a gently sloping, free-draining topography. Replace topsoil to 350 mm and rip soil to 200 mm to reduce compaction, thereafter, establish successful vegetation cover. Remove alien invasive vegetation. Monitor required aspects according to guidelines stipulated in specialist reports appended to the EIA.

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11.3 Remediation of environmental impacts

Topsoil Stockpiles

Replace correct topsoil and rip soil to 200 mm to reduce compaction, thereafter, establish successful vegetation cover. Remove alien invasive vegetation. Monitor required aspects according to guidelines stipulated in specialist reports appended to the EIA.

12 Conclusion and Recommendations

12.1 Conclusion and Summary

- The dominant water type in this area is Calcium/ magnesium/sulphate chloride water.
- The pollution plume at the end of life of mine is used as the starting point for the long-term plume development.
- The site topography is best described as being relatively flat with little topographical features. On site the topography dip towards the north-northwest. Topographical elevation at the farm Hooikraal in the south is recorded at around 920 mamsl, while topography in the north-northwest of the mining lease area ranges between 890 and 885 mamsl.
- No surface water bodies are recorded on site. In addition, no surface water bodies, perennial or non-perennial, are indicated on the relevant site maps.
- Two aquifers occur in the area. These two aquifers are associated with a) the weathered material, and b) the underlying fractured rock material.
- The upper aquifer forms due to the vertical infiltration of recharging rainfall through the weathered material being retarded by the lower permeability of the underlying competent rock material. Groundwater collecting above the weather / unweathered material contact migrates down gradient along the contact to lower lying areas
- Drilling results show that the upper aquifer in the vicinity of the proposed opencast pit area has an average maximum depth of around 15 m, and consists of a medium to fine grained sandy material
- Borehole yields of the upper aquifer will be seasonally variable and it is considered that around 1 to 2 % of effective recharge from rainfall takes place (taking into consideration the 3 000 mm/a evaporation and seasonality)
- Groundwater flows in the lower aquifer is associated with the secondary fracturing in the competent rock and as such will be along discrete pathways associated with the fractures. Major faults such as the Eenzaamheid fault can be a major source of groundwater, depending

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on whether the fractures have been filled with subsequent crystallisation of quartz or other minerals

- Depth to groundwater level generally ranges between 20 and 60 mbgl. Plotting groundwater level elevation versus topographical elevation for this area yields a 73 % correlation. Thus it can be concluded that groundwater flow directions follow topography albeit at a shallower gradient and is directed in a north-north westerly direction. Groundwater flow gradients are calculated at between 1:200 and 1:300;
- The groundwater quality generally conforms to the Class 0 and Class 1 standards which is acceptable for human consumption. In general, it can be said that the groundwater quality does not pose a health risk, although there are some concerns regarding aesthetic aspects; and
- The groundwater is generally of good quality and conforms to Class 0 and Class 1 SABS 241 guidelines for domestic use.

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12.2 Recommendations

Aspect	Recommendation
Monitoring	• Conduct water monitoring and implement remedial actions as required and effective rehabilitation to as close to pre-mining conditions as practically possible. • It is recommended that the monitoring network be extended to all the boundaries; north, south, east and west of the proposed mining right. The construction must be overseen by a qualified Hydrogeologist to monitor pollution in the upper weathered aquifer as well as the lower fractured aquifer. • A monitoring network should be dynamic. This means that the network should be extended over time to accommodate the migration of contaminants through the aquifer as well as the expansion of infrastructure and/or addition of possible pollution sources. An audit on the monitoring network should be conducted annually
Modelling	• The numerical model should be recalibrated as soon as more hydrogeological data such as monitoring holes are made available. This would enhance model predictions and certainty
Water contamination	• Prevention of pollution of surface water resources and impacts on other surface water users by training of workers to prevent pollution, equipment and vehicle maintenance, fast and effective clean-up of spills, effective waste management, manage clean and dirty water in accordance
Flow of water	• The disturbance of streams and surface drainage patterns and reduction in flow to downstream must be mitigated through careful design of ephemeral stream diversion that minimizes impacts on the downstream environment, limit activities and infrastructure within wetland and watercourses and their floodlines and implementation of storm water management plan to divert clean water • **Clean water trenches** should be constructed surrounding the mining right to prevent clean water from entering the mining area, regarded as a dirty water catchment • **Dirty water trenches** must be constructed as well to direct water from the mine to the pollution control dam, thereby preventing any contaminant water from leaving the mine area.

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Appendices

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Appendix A: Hydrocensus table

Project name	Lephalale Coal Concession			Prepared by	Singo Consulting (Pty) Ltd						
Borehole ID	Latitude	Longitude	Hydrocensus date	Diameter(mm)	Static water level(mbgl)	Borehole depth (mbgl)	Sample taken	Current use	Casing	Date drilled	Comments
HK 01	-23,701022	27,434892	04/09/2020	165	40,37	160,45	Yes	Exploration borehole	Steel	28/07/2020	Light brown water sample, not closed
HK 02	-23,700059	27,4377	04/09/2020	225	43,95	172,51	yes	Exploration borehole	Steel	21/08/2020	Dark brown to black water sample, Closed with wood, unkept evironment with oils from the drill rig
HK 03	-23,701022	27,434892	04/09/2020	165	40,07	166,58	yes	Exploration borehole	Steel	03/08/2020	Black water sample with bad odor,
HK 04	-23,696716	27,43354	05/09/2020	165	38,8	169,51	yes	Exploration borehole	Steel	13/08/2020	Dark brown to black water sample, Closed with wood, unkept evironment with oils from the drill rig
HK 05	-23,696654	27,4335226	04/09/2020	165	38,34	166,49	yes	Exploration borehole	Steel	31/08/2020	Black water sample with bad odor,
Percussion BH 1	-23,697953	27,436051	05/09/2020	N/A	Dry	N/A	No	Percussion borehole	None	N/A	Poorly constructed borehole with no casing
Monitoring BH 1	-23,700341	27,437665	05/09/2020	225	N/A	N/A	No	Groundwater Monitoring Borehole	Steel	N/A	Locked with Key, properly constructed borehole
SLCC-BH1	-23,702102	27,434382	05/09/2020	225	N/A	N/A	yes	Running water being pumped to the reservoir and used for dust suppression	Steel	2017	Well constructed borehole, which pumps 3000l/h, clear colour water sample was collected
SLCC-BH2	-23,703065	27,434415	05/09/2020	225	N/A	N/A	yes	Running water being pumped to the reservoir and used for dust suppression snd to water the law	Steel	2017	Well construc ted borehole, which pumps 4500l/h, clear colour water sample was collected
SLCC-BH3	-23,699771	27,450003	05/09/2020	165	Dry	N/A	No	N/A	Steel	N/A	Old Borehole cased and not closed
SLCC-BH4	-23,701348	27,457967	05/09/2020	225	53,31	N/A	yes	N/A	Steel	07/2020	This borehole is planned to be used for the wash plant. The water will be pumped into dams and used for the wash plant.
SLCC-BH5	-23,701288	27,457971	05/09/2020	225	53,65	N/A	yes	N/A	Steel	07/2020	Clear water sample
SLCC-BH6	-23,701463	27,43671	05/09/2020	N/A	Dry	100	No	N/A	None	08/2020	Poorly constructed borehole with no casing
SLCC-BH7	-23,694276	27,436858	05/09/2020	N/A	Dry	N/A	No	N/A	None	08/2020	Poorly constructed borehole with no casing
SLCC-BH8 (Percussion BH)	-23,698159	27,4354	05/09/2020	N/A	Dry	N/A	No	Percussion borehole	None	N/A	Poorly constructed borehole with no casing
SLCC-BH9	-23,707163	27,450647	05/09/2020	N/A	N/A	N/A	yes	Used for farmhouse activities (including drinking water)	Steel	N/A	Well constructed borehole, clear colour water sample was collected
SLCC-BH10	-23,656225	27,412029	05/09/2020	225	31,26	N/A	yes	N/A	Steel	N/A	Well constructed borehole, brackish colour water sample was collected, closed and cased.
SLCC-Reservoir	-23,703065	27,434415	05/09/2020	255	N/A	N/A	yes	Borehole water pumping to borehole	Steel	N/A	Well constructed borehole, clear colour water sample was collected, closed and cased.
R303712 (Monitoring BH)	-23,673469	27,408699	06/09/2020	165	34,46	N/A	yes	N/A	Steel	N/A	Monitoring borehole, yellowish color water sample
SLCC-PS306025	-23,66015	27,406389	06/09/2020	225	32,05	N/A	yes	N/A	Steel	N/A	Not in use, cased and not closed
SLCC-BH11	-23,656253	27,412023	06/09/2020	165	30,52	N/A	yes	N/A	Steel	N/A	Poorly caped, damaged casing, rusted casing, brown water sample
SLCC-BH12	-23,647627	27,423215	06/09/2020	165	30,5	N/A	yes	N/A	Steel	N/A	Not capped, rusted casing, bad odor water, brown water sample
SLCC-BH13	-23,63374	27,424219	06/09/2020	165	31,41	N/A	yes	Monitoring borehole	Steel	N/A	Properly constructed borehole, closed with steel casing, light black color water sample
SLCC-BH14	-23,619397	27,406151	06/09/2020	225	28,6	N/A	yes	N/A	Plastic	N/A	Steel stick out with plastic inner casing, clear color water sample
SLCC-BH15	-23,639702	27,393785	06/09/2020	165	28,49	N/A	yes	N/A	Plastic	N/A	Steel stick out with plastic inner casing, clear color water sample
SLCC-BH16 (003)	-23,639717	27,393781	06/09/2020	165	Dry	N/A	No	N/A	Steel	N/A	Dry borehole
SLCC-BH17	-23,656111	27,402883	06/092020	225	29,01	N/A	yes	N/A	Steel	N/A	Properly constructed borehole, closed with steel casing, clear color water sample
SLCC-BH18 (053)	-23,656155	27,402878	06/09/2020	165	30,4	N/A	yes	N/A	Steel	N/A	Properly constructed borehole, closed with steel casing, dark brown color water sample
SLCC-BH19	-23,657963	27,404069	06/09/2020	165	N/A	N/A	yes	Farmhouse borehole	Steel	2018	Clear water sample
SLCC-BH20	-23,65368	27,416657	07/09/2020	N/A	60	90	yes	Pumped to the reservoir and used at the lodge and the farmhouse.	Steel	N/A	Pumps about 1500l/h to the resrvoir located at the farmhouse
SLCC-BH21	-23,680182	27,429703	07/09/2020	N/A	60	100	No	Used for animals	Steel	N/A	Pumps about 1000l/h to the tank
ZAAIMAN-PM3ST001	-23,661866	27,425578	07/09/2020	165	39,15	N/A	Yes	N/A	Steel	N/A	Drilled about 13years ago and current;y not in use. Pumps about 4000l/h. light black color water sample
PM35T002	-23,6554991	27,421787	07/09/2020	165	30	113	Yes	N/A	Steel	N/A	Clear water, cased and caped, bad odor water sample, pumps about 3000l/h
SLCC-BH22	-23,647153	27,431541	07/09/2020	165	Dry	N/A	No	Monitoring borehole	Steel	N/A	Dry borehole
SLCC-BH23	-23,654391	27,416852	07/09/2020	165	N/A	N/A	Yes	Used for irrigation	Steel	Jan-20	Drilled about 8months ago and current;y not in use, was drilled with the intention to be used for irrigation. Pumps about 900l/h. clear color water sample

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Appendix B: Geophysical Investigation Traverses (Future Flow GPMS cc, Sekoko Waterberg Project Coal Mine, groundwater EIA study, 2011)

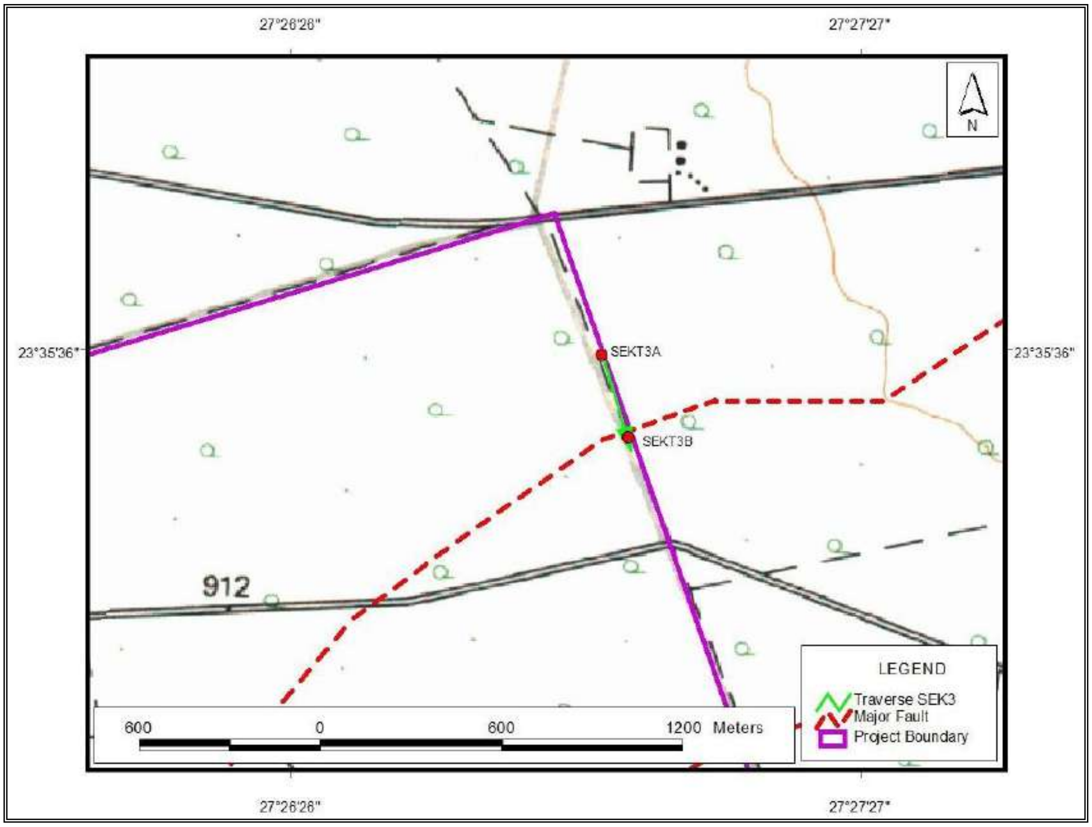

Figure A1. Ground magnetic traverse at Minnasvlakte.

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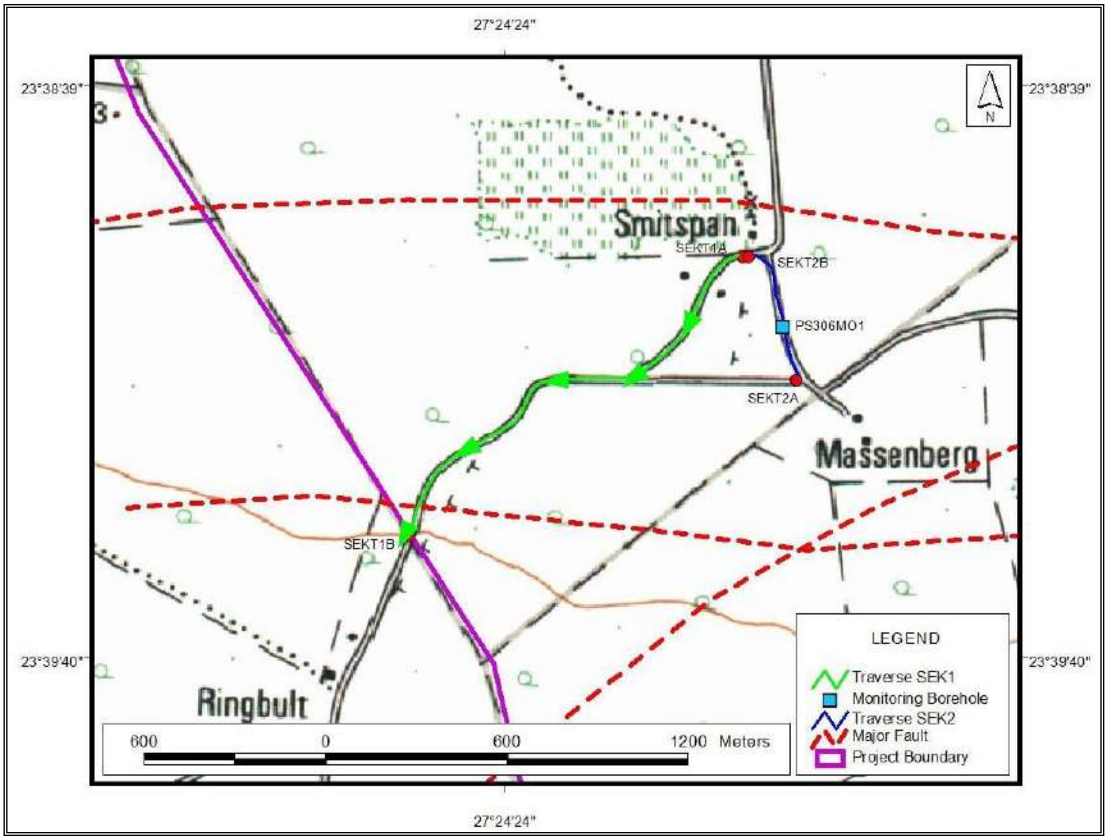

Figure A2. Ground magnetic traverse at Smitspan.

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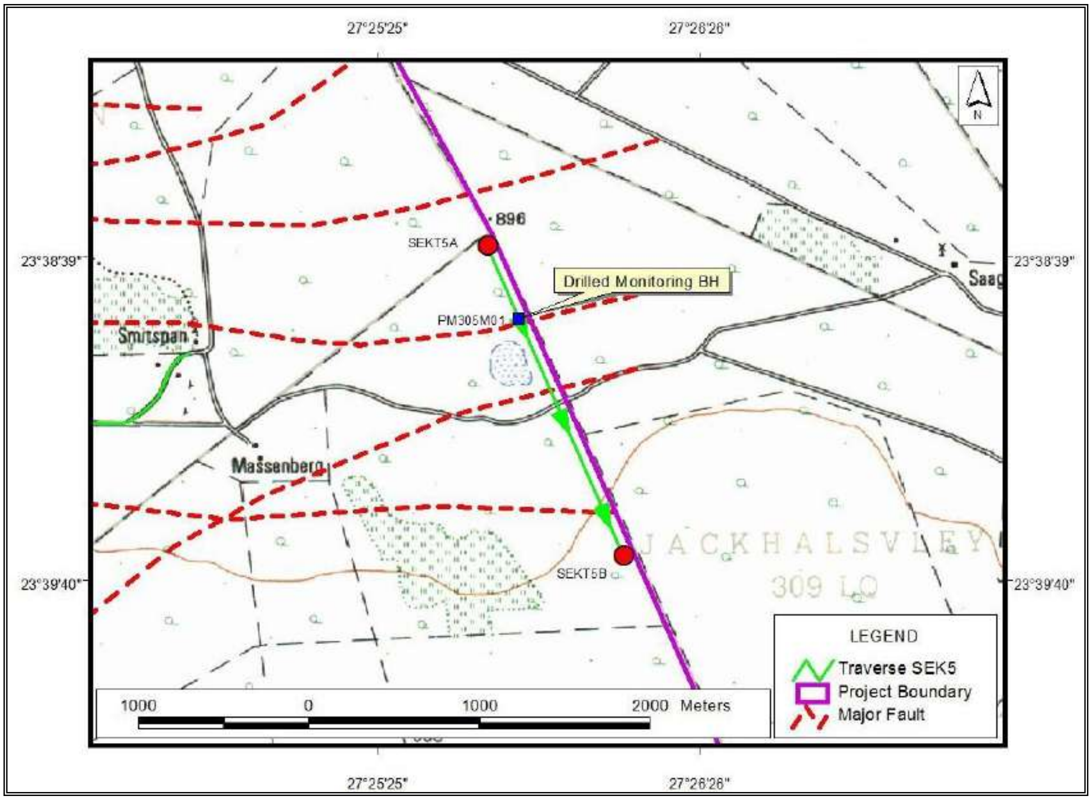

Figure A3. Ground magnetic traverse at Massenberg.

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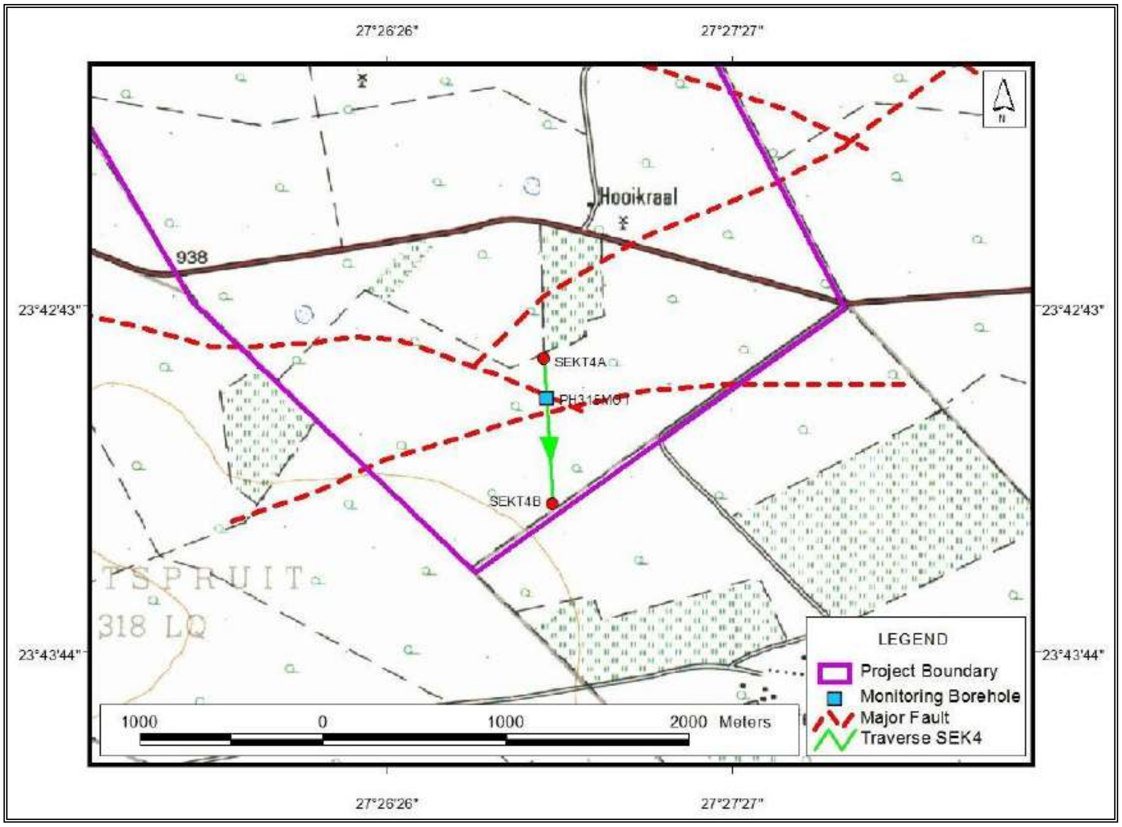

Figure A4. Ground magnetic traverse at Hooikraal.

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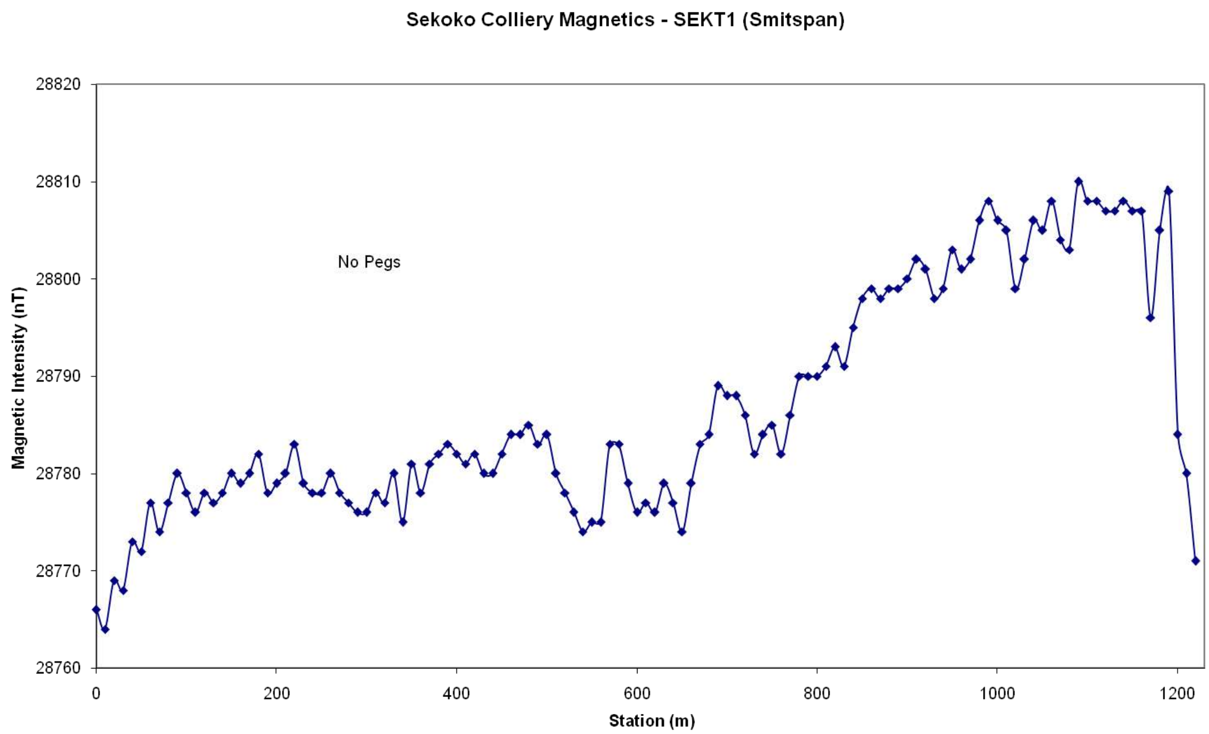

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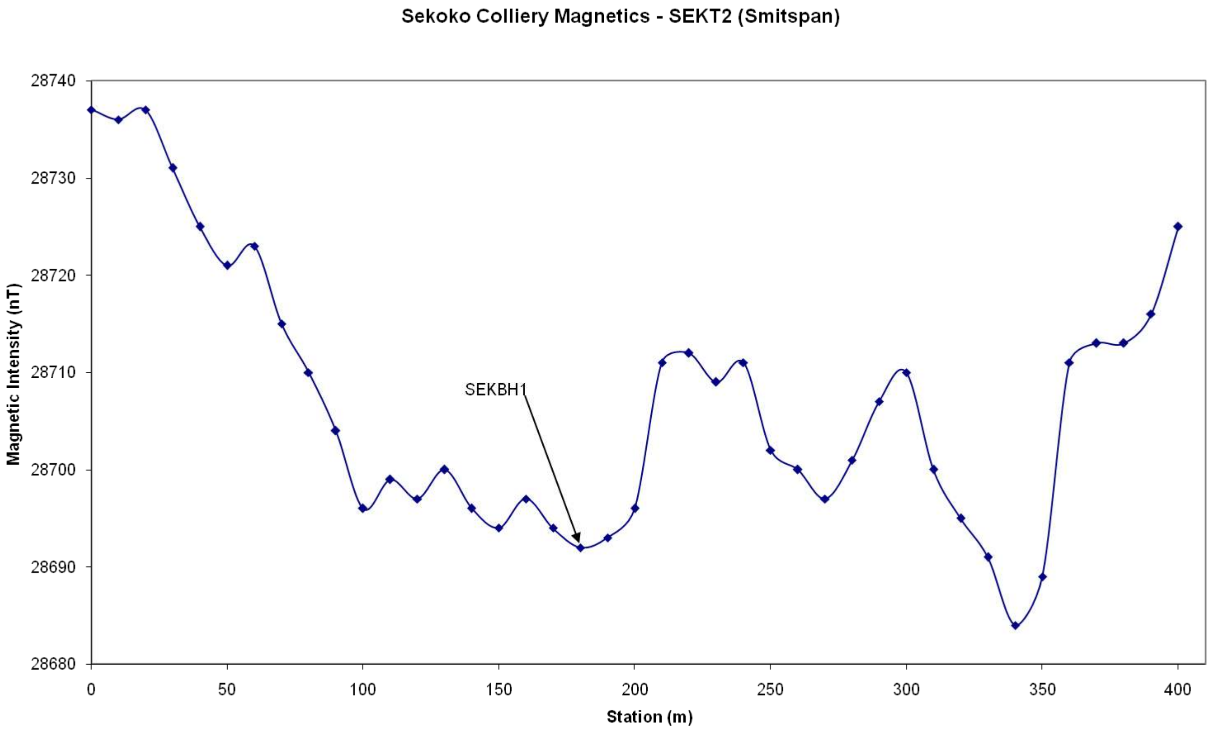

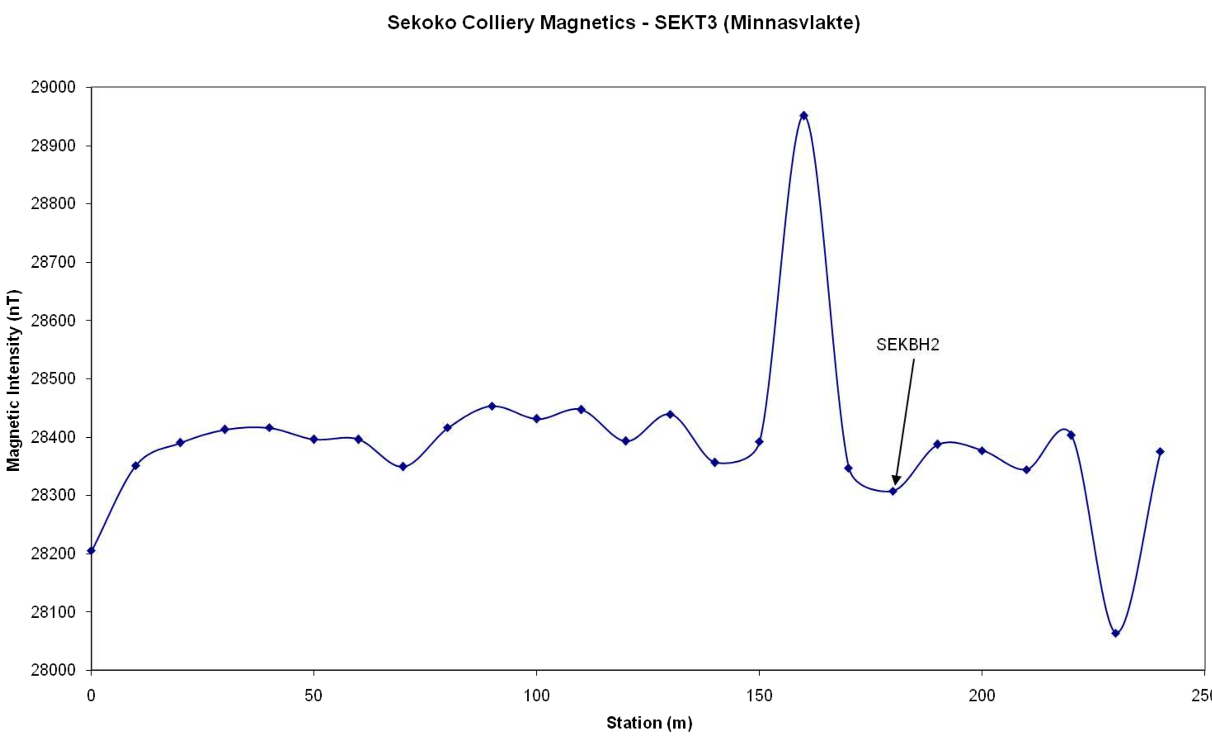

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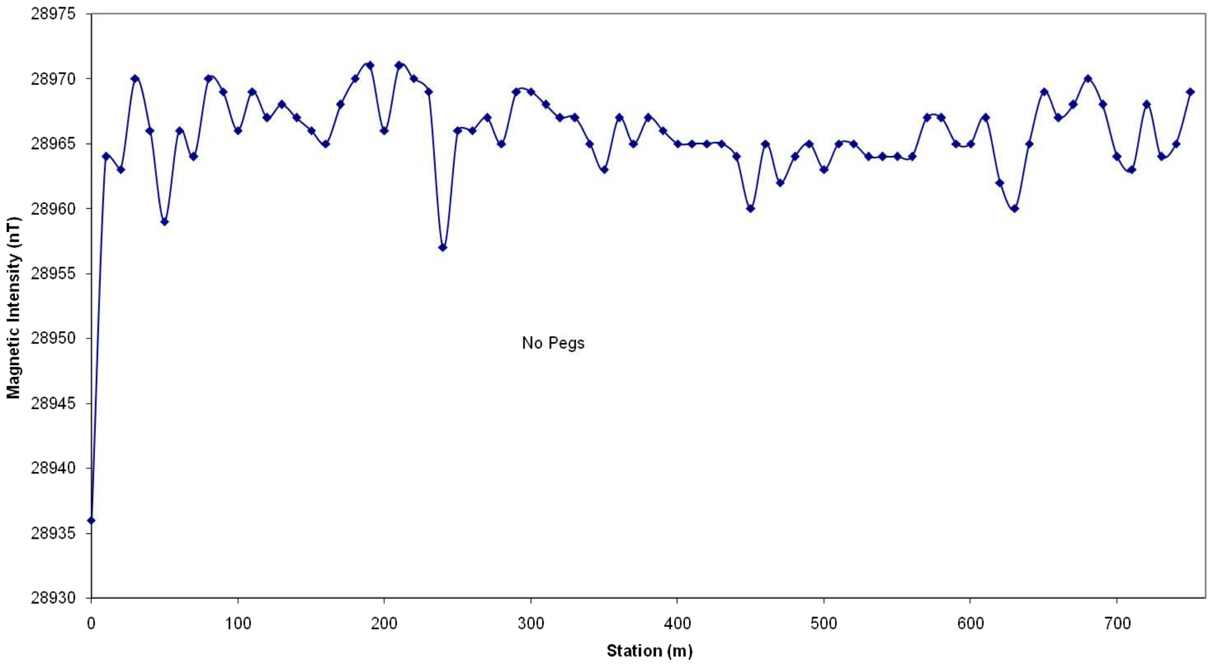
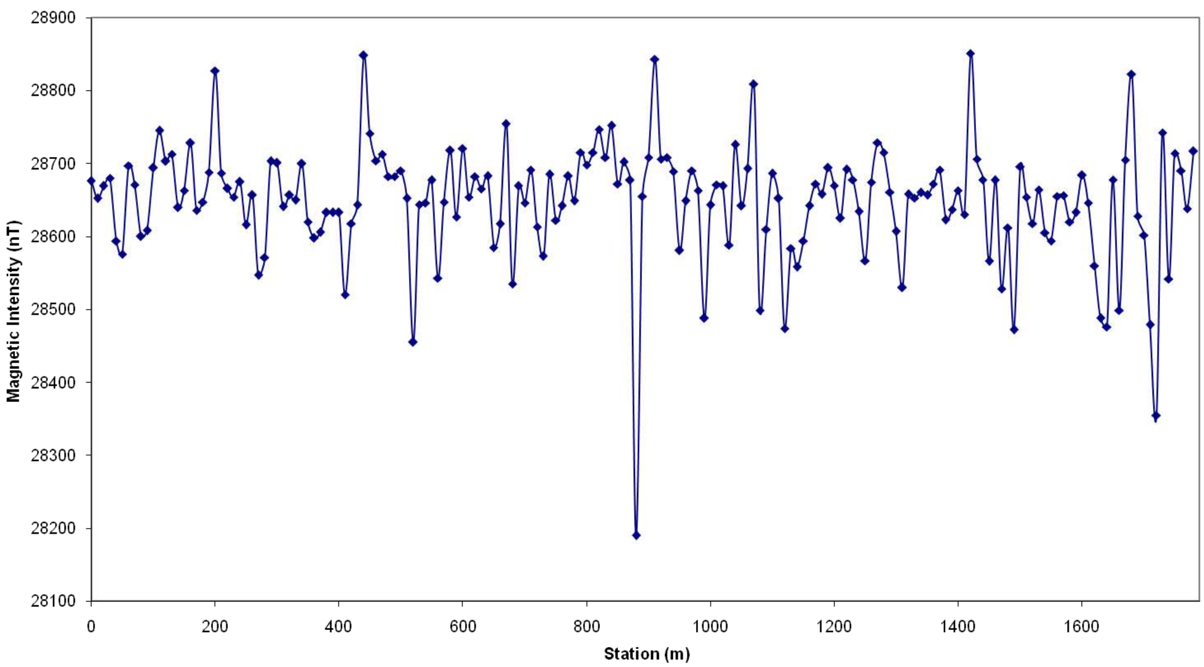
Sekoko Colliery Magnetics - SEKT5 (Hooikraal)



Sekoko Colliery Magnetics - SEKT4 (Massenberg)



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Appendix C: Hydrocensus forms

HYDROCENSUS OF GROUNDWATER

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Project name:	Lephalale Coal Concessions		
Census date:	04/08/2020	Field Technician	Singo Consulting land and water division team

Site information

Owner:	Lephalale Coal Concessions		
Address:	Lephalale, Limpopo	Cell:	0824495329 (Phillip De Lange)
South Africa		Tel:	

Borehole/monitoring well info

Borehole number:	HK01	In use:	Yes		No	X			
Y-coordinate:(south)	27,434892	When last pumped	Hours		Days		Currently	N/A	X
X-coordinate:(East)	-23,701022	Pump type	Sub		Wind		Mono	None	
Z-coordinate:	mamsl	Depth to water table: (SWL)	40.37	mbgl	No access				
Diameter:	165mm X	225mm	Sample taken	Yes	X	No			
Collar height:	Level	mm	Float/pump sample:	None	X	Pump	Tank		

Water Application

Garden/Landscape:	Garden		Veg.		Mix		Cotton		Fruits		Grains		Feed		Other	x
Area of garden/crop:		ha		ha		ha		ha		ha		ha		ha		ha
Livestock watering:	horses		poultry		pigs		Pigs/goats		cattle		Fish		N/A	X	Other	
No.of:																
Aqua farming:	yes		No	X	Volume and no. of tanks											
Domestic:	No. of households								or		No.of people					
Other uses:	Exploration borehole															
Possible future use:																

Additional Borehole Information

Date drilled:	28/07/2020		Depth of water strikes	40.37				
Depth drilled:	160.45 mbgl		Pump size			Kw		
Casing type	Steel		Yield		Gal		l/h	
	Plastic		Pump to reservoir:	Yes		No		Volume
Depth of casing		m	How often pumped:	As needed		Daily		
Length of perforated casing		m		Auto level control				

Notes	Photo
Open, not well constructed borehole.	
Light brown water sample, not closed	

HYDROCENSUS OF GROUNDWATER

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Project name:	Lephalale Coal Concessions										
Census date:	04/08/2020			Field Technician	Singo Consulting land and water division team						
Site information											
Owner:	Lephalale Coal Concessions										
Address:	Lephalale, Limpopo			Cell:	0824495329 (Phillip De Lange)						
South Africa				Tel:							
Borehole/monitoring well info											
Borehole number:	HK02			In use:	Yes		No		X		
Y-coordinate:(south)	27,4377			When last pumped	Hours		Days		Currently		N/A X
X-coordinate:(East)	-23,700059			Pump type	Sub		Wind		Mono		None
Z-coordinate:		mamsl	Depth to water table: (SWL)		43.95		mbgl		No access		
Diameter:	165mm	X	225mm	Sample taken	Yes	X	No				
Collar height:	Level		mm	Float/pump sample:	None	X	Pump		Tank		
Water Application											
Garden/Landscape:	Garden		Veg.		Mix		Cotton	Fruits	Grains	Feed	Other x
Area of garden/crop:	ha		ha		ha		ha	ha	ha	ha	ha
Livestock watering:	horses		poultry		pigs		Pigs/goats	cattle	Fish	N/A X	Other
No.of:											
Aqua farming:	yes		No	X	Volume and no. of tanks						
Domestic:	No. of households						or	No.of people			
Other uses:	Exploration borehole										
Possible future use:											
Additional Borehole Information											
Date drilled:	21/08/2020		Depth of water strikes		43.95						
Depth drilled:	172.51 mbgl		Pump size					Kw			
Casing type	Steel		Yield			Gal			l/h		
	Plastic		Pump to reservoir:		Yes		No		Volume		
Depth of casing		m	How often pumped:		As needed			Daily			

Length of perforated casing		m			Auto level control	

Notes	Photo
Open, not well constructed borehole.	
Black water sample, not closed	
unkept environment with oils from the drill rig	

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Project name:	Lephalale Coal Concessions		
Census date:	04/08/2020	Field Technician	Singo Consulting land and water division team
Site information			
Owner:	Lephalale Coal Concessions		
Address:	Lephalale, Limpopo	Cell:	0824495329 (Phillip De Lange)
South Africa		Tel:	

Borehole/monitoring well info											
Borehole number:	HK03			In use:	Yes		No		X		
Y-coordinate:(south)	27,434892			When last pumped	Hours		Days		Currently	N/A	X
X-coordinate:(East)	-23,701022			Pump type	Sub		Wind		Mono	None	
Z-coordinate:		mamsl		Depth to water table: (SWL)	40.07		mbgl		No access		
Diameter:	165mm	X	225mm		Sample taken	Yes	X	No			
Collar height:	Level			mm	Float/pump sample:	None	X	Pump	Tank		

Water Application																
Garden/Landscape:	Garden		Veg.		Mix		Cotton		Fruits		Grains		Feed		Other	x
Area of garden/crop:		ha		ha		ha		ha		ha		ha		ha		ha
Livestock watering:	horses		poultry		pigs		Pigs/goats		cattle		Fish		N/A	X	Other	
No.of:																
Aqua farming:	yes		No	X	Volume and no. of tanks											
Domestic:	No. of households										or		No.of people			
Other uses:	Exploration borehole															

Possible future use:								
Additional Borehole Information								
Date drilled:	3/08/2020		**Depth of water strikes**	40.07				
Depth drilled:	166.58 mbgl		**Pump size**			**Kw**		
Casing type	**Steel**		**Yield**		**Gal**		**l/h**	
	Plastic		**Pump to reservoir:**	**Yes**		**No**		**Volume**
Depth of casing	**m**		**How often pumped:**	**As needed**		**Daily**		
Length of perforated casing	**m**			**Auto level control**				

Notes	**Photo**
Open, not well constructed borehole.	
Black water sample with bad odor,	

Singo Consulting (Pty) Ltd

HYDROCENSUS OF GROUNDWATER

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Project name:	Lephalale Coal Concessions		
Census date:	04/08/2020	**Field Technician**	Singo Consulting land and water division team
Site information			
Owner:	Lephalale Coal Concessions		
Address:	Lephalale, Limpopo	**Cell:**	0824495329 (Phillip De Lange)
South Africa		**Tel:**	

Borehole/monitoring well info										
Borehole number:	HK04		**In use:**	Yes		No			X	
Y-coordinate:(south)	27,43354		**When last pumped**	Hours		Days		Currently	N/A	X
X-coordinate:(East)	-23,696716		**Pump type**	Sub		Wind		Mono	None	
Z-coordinate:		mamsl	**Depth to water table: (SWL)**	38.8		mbgl		No access		
Diameter:	165mm X	225mm	**Sample taken**	Yes	X	No				
Collar height:	Level	mm	**Float/pump sample:**	None	X	Pump		Tank		
Water Application										

Garden/Landscape:	**Garden**		**Veg.**		**Mix**		**Cotton**		**Fruits**		**Grains**		**Feed**		**Other**	**x**
Area of garden/crop:		**ha**		**ha**		**ha**		**ha**		**ha**		**ha**		**ha**		**ha**
Livestock watering:	**horses**		**poultry**		**pigs**		**Pigs/goats**		**cattle**		**Fish**		**N/A**	**X**	**Other**	
No.of:																
Aqua farming:	**yes**		**No**	**X**	**Volume and no. of tanks**											
Domestic:	**No. of households**										**or**	**No.of people**				
Other uses:	**Exploration borehole**															
Possible future use:																

Additional Borehole Information								
Date drilled:	**13/08/2020**		**Depth of water strikes**	**38.8**				
Depth drilled:	**169.51 mbgl**		**Pump size**			**Kw**		
Casing type	**Steel**		**Yield**		**Gal**		**l/h**	
	Plastic		**Pump to reservoir:**	**Yes**		**No**		**Volume**
Depth of casing	**m**		**How often pumped:**	**As needed**		**Daily**		
Length of perforated casing	**m**			**Auto level control**				

Notes	**Photo**
Dark brown to black water sample	
Closed with wood	

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HYDROCENSUS OF GROUNDWATER

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Project name:	**Lephalale Coal Concessions**				
Census date:	**04/08/2020**	**Field Technician**	**Singo Consulting land and water division team**		
Site information					
Owner:	**Lephalale Coal Concessions**				
Address:	**Lephalale, Limpopo**	**Cell:**	**0824495329 (Phillip De Lange)**		
South Africa		**Tel:**			
Borehole/monitoring well info					
Borehole number:	**HK05**	**In use:**	**Yes**	**No**	**X**

Y-coordinate:(south)	27,4335226			When last pumped	Hours		Days		Currently		N/A	X			
X-coordinate:(East)	-23,696654			Pump type	Sub		Wind		Mono		None				
Z-coordinate:		mamsl	Depth to water table: (SWL)		38.34		mbgl		No access						
Diameter:	165mm	X	225mm	Sample taken	Yes	X	No								
Collar height:	Level		mm	Float/pump sample:	None	X	Pump		Tank						
Water Application															
Garden/Landscape:	Garden		Veg.		Mix		Cotton		Fruits		Grains		Feed		Other x
Area of garden/crop:		ha		ha		ha		ha		ha		ha		ha	ha
Livestock watering:	horses		poultry		pigs		Pigs/goats		cattle		Fish		N/A	X	Other
No.of:															
Aqua farming:	yes		No	X	Volume and no. of tanks										
Domestic:	No. of households							or	No.of people						
Other uses:	Exploration borehole														
Possible future use:															
Additional Borehole Information															
Date drilled:	31/08/2020		Depth of water strikes		38.34										
Depth drilled:	166.49 mbgl		Pump size				Kw								
Casing type	Steel		Yield			Gal			l/h						
	Plastic		Pump to reservoir:		Yes		No		Volume						
Depth of casing		m	How often pumped:		As needed		Daily								
Length of perforated casing		m			Auto level control										

Notes

Black water sample with bad odor,

Photo

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HYDROCENSUS OF GROUNDWATER

Project name:	Lephalale Coal Concessions		
Census date:	04/08/2020	Field Technician	Singo Consulting land and water division team
Site information			
Owner:	Lephalale Coal Concessions		
Address:	Lephalale, Limpopo	Cell:	0824495329 (Phillip De Lange)
South Africa		Tel:	

Borehole/monitoring well info										
Borehole number:	Percussion BH 1		In use:	Yes		No		X		
Y-coordinate:(south)	27,436051		When last pumped	Hours		Days		Currently	N/A	X
X-coordinate:(East)	-23,697953		Pump type	Sub		Wind		Mono	None	
Z-coordinate:		mamsl	Depth to water table: (SWL)		mbgl			No access		
Diameter:	165mm X	225mm	Sample taken	Yes		No	X			
Collar height:	Level	mm	Float/pump sample:	None	X	Pump		Tank		

Water Application																
Garden/Landscape:	Garden		Veg.		Mix		Cotton		Fruits		Grains		Feed		Other	x
Area of garden/crop:		ha		ha		ha		ha		ha		ha		ha		ha
Livestock watering:	horses		poultry		pigs		Pigs/goats		cattle		Fish		N/A	X	Other	
No.of:																
Aqua farming:	yes		No	X	Volume and no. of tanks											
Domestic:	No. of households								or		No.of people					
Other uses:	Percussion borehole															
Possible future use:																

Additional Borehole Information								
Date drilled:			Depth of water strikes					
Depth drilled:			Pump size			Kw		
Casing type	Steel		Yield		Gal		l/h	
	Plastic		Pump to reservoir:	Yes		No		Volume
Depth of casing		m	How often pumped:	As needed		Daily		
Length of perforated casing		m		Auto level control				

Notes	Photo
Poorly constructed borehole with no casing	
No water sample	

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Project name:	**Lephalale Coal Concessions**		
Census date:	**05/08/2020**	**Field Technician**	**Singo Consulting land and water division team**
Site information			
Owner:	**Lephalale Coal Concessions**		
Address:	**Lephalale, Limpopo**	**Cell:**	**0824495329 (Phillip De Lange)**
South Africa		**Tel:**	

Borehole/monitoring well info											
Borehole number:	**Monitoring BH 1**				**In use:**	**Yes**		**No**		**X**	
Y-coordinate:(south)	**27,437665**				**When last pumped**	**Hours**		**Days**	**Currently**	**N/A**	**X**
X-coordinate:(East)	**-23,700341**				**Pump type**	**Sub**		**Wind**	**Mono**	**None**	
Z-coordinate:		**mamsl**	**Depth to water table: (SWL)**					**mbgl**	**No access**		
Diameter:	**165mm**		**225mm**	**X**	**Sample taken**	**Yes**		**No**	**X**		
Collar height:	**Level**			**mm**	**Float/pump sample:**	**None**	**X**	**Pump**		**Tank**	

Water Application																
Garden/Landscape:	**Garden**		**Veg.**		**Mix**		**Cotton**		**Fruits**		**Grains**		**Feed**		**Other**	**x**
Area of garden/crop:		**ha**		**ha**		**ha**		**ha**		**ha**		**ha**		**ha**		**ha**
Livestock watering:	**horses**		**poultry**		**pigs**		**Pigs/goats**		**cattle**		**Fish**		**N/A**	**X**	**Other**	
No.of:																
Aqua farming:	**yes**		**No**	**X**	**Volume and no. of tanks**											
Domestic:	**No. of households**									**or**	**No.of people**					
Other uses:	**Groundwater Monitoring Borehole**															
Possible future use:																

Additional Borehole Information									
Date drilled:			**Depth of water strikes**						
Depth drilled:			**Pump size**				**Kw**		
Casing type	**Steel**		**Yield**		**Gal**			**l/h**	
	Plastic		**Pump to reservoir:**	**Yes**		**No**		**Volume**	
Depth of casing		**m**	**How often pumped:**	**As needed**			**Daily**		

Length of perforated casing		**m**			**Auto level control**	

Notes	**Photo**
Groundwater Monitoring Borehole	
No water sample	
Locked with Key, properly constructed borehole	

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Project name:	**Lephalale Coal Concessions**		
Census date:	**05/08/2020**	**Field Technician**	**Singo Consulting land and water division team**
Site information			
Owner:	**Lephalale Coal Concessions**		
Address:	**Lephalale, Limpopo**	**Cell:**	**0824495329 (Phillip De Lange)**
South Africa		**Tel:**	

Borehole/monitoring well info												
Borehole number:	**SLCC-BH1**				**In use:**	**Yes**		**X**	**No**			
Y-coordinate:(south)	**27,434382**				**When last pumped**	**Hours**	**X**	**Days**		**Currently**		**N/A**
X-coordinate:(East)	**-23,702102**				**Pump type**	**Sub**		**Wind**		**Mono**		**None**
Z-coordinate:		**mamsl**	**Depth to water table: (SWL)**					**mbgl**		**No access**		
Diameter:	**165mm**		**225mm**	**X**	**Sample taken**	**Yes**	**X**	**No**				
Collar height:	**Level**			**mm**	**Float/pump sample:**	**None**	**X**	**Pump**		**Tank**		

Water Application																	
Garden/Landscape:	**Garden**		**Veg.**		**Mix**		**Cotton**		**Fruits**		**Grains**		**Feed**		**Other**		**x**
Area of garden/crop:		**ha**		**ha**		**ha**		**ha**		**ha**		**ha**		**ha**			**ha**

Livestock watering:	**horses**		**poul try**		**pigs**		**Pigs/goats**		**cattle**		**Fish**		**N/ A**	X	**Other**	
No.of:																
Aqua farming:	**yes**		**No**	X	**Volume and no. of tanks**											
Domestic:	**No. of households**									**or**	**No. of people**					
Other uses:																
Possible future use:																

Additional Borehole Information									
Date drilled:	2017			**Depth of water strikes**					
Depth drilled:				**Pump size**			**Kw**		
Casing type	**Steel**			**Yield**		**Gal**		**l/h**	
	Plastic			**Pump to reservoir:**	**Yes**		**No**		**Volum e**
Depth of casing		**m**		**How often pumped:**	**As needed**			**Daily**	
Length of perforated casing		**m**			**Auto level control**				

Notes	**Photo**
Running water being pumped to the reservoir and used for dust suppression	
water sample taken	
Well constructed borehole, which pumps 3000l/h, clear colour water sample was collected	

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Project name:	**Lephalale Coal Concessions**											
Census date:	**05/08/2020**				**Field Technician**	**Singo Consulting land and water division team**						
Site information												
Owner:	**Lephalale Coal Concessions**											
Address:	**Lephalale, Limpopo**				**Cell:**	**0824495329 (Phillip De Lange)**						
South Africa					**Tel:**							
Borehole/monitoring well info												
Borehole number:	SLCC-BH2				**In use:**	**Yes**		X	**No**			
Y-coordinate:(south)	27,434415				**When last pumped**	**Hours**	X	**Days**		**Currently**		**N/A**
X-coordinate:(East)	-23,703065				**Pump type**	**Sub**		**Wind**		**Mono**		**None**
Z-coordinate:		**mamsl**	**Depth to water table: (SWL)**					**mbgl**		**No access**		
Diameter:	**165mm**		**225mm**	X	**Sample taken**	**Yes**	X	**No**				

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Collar height:	Level			mm	Float/pump sample:	None		Pump	X	Tank	

Water Application

Garden/Landscape:	Garden		Veg.		Mix		Cotton		Fruits		Grains		Feed		Other	x
Area of garden/crop:		ha		ha		ha		ha		ha		ha		ha		ha
Livestock watering:	horses		poultry		pigs		Pigs/goats		cattle		Fish		N/A	X	Other	
No.of:																
Aqua farming:	yes		No	X	Volume and no. of tanks											
Domestic:	No. of households								or		No. of people					
Other uses:																
Possible future use:																

Additional Borehole Information

Date drilled:	2017			Depth of water strikes					
Depth drilled:				Pump size			Kw		
Casing type	Steel			Yield		Gal		l/h	
	Plastic			Pump to reservoir:	Yes		No		Volume
Depth of casing		m		How often pumped:	As needed		Daily		
Length of perforated casing		m			Auto level control				

Notes	Photo
Running water being pumped to the reservoir and used for dust suppression and to water the lawn	
water sample taken	
Well constructed borehole, which pumps 4500l/h, clear colour water sample was collected	

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Project name:	Lephalale Coal Concessions		
Census date:	05/08/2020	Field Technician	Singo Consulting land and water division team

Site information			
Owner:	Lephalale Coal Concessions		
Address:	Lephalale, Limpopo	Cell:	0824495329 (Phillip De Lange)
South Africa		Tel:	

Borehole/monitoring well info												
Borehole number:	SLCC-BH3				In use:	Yes		No		X		
Y-coordinate:(south)	27,450003				When last pumped	Hours		Days		Currently	N/A	X
X-coordinate:(East)	-23,699771				Pump type	Sub		Wind		Mono	None	
Z-coordinate:		mamsl	Depth to water table: (SWL)					mbgl		No access		
Diameter:	165mm	X	225mm		Sample taken	Yes		No	X			
Collar height:	Level			mm	Float/pump sample:	None		Pump	X	Tank		

Water Application															
Garden/Landscape:	Garden		Veg.		Mix		Cotton		Fruits		Grains		Feed		Other x
Area of garden/crop:		ha		ha		ha		ha		ha		ha		ha	ha
Livestock watering:	horses		poultry		pigs		Pigs/goats		cattle		Fish		N/A	X	Other
No.of:															
Aqua farming:	yes		No	X	Volume and no. of tanks										
Domestic:	No. of households								or		No. of people				
Other uses:															
Possible future use:															

Additional Borehole Information									
Date drilled:				Depth of water strikes					
Depth drilled:				Pump size			Kw		
Casing type	Steel			Yield		Gal		l/h	
	Plastic			Pump to reservoir:	Yes		No		Volume
Depth of casing		m		How often pumped:	As needed		Daily		
Length of perforated casing		m			Auto level control				

Notes	Photo
Old Borehole cased and not closed	
No water sample taken	

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